COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

November 1951

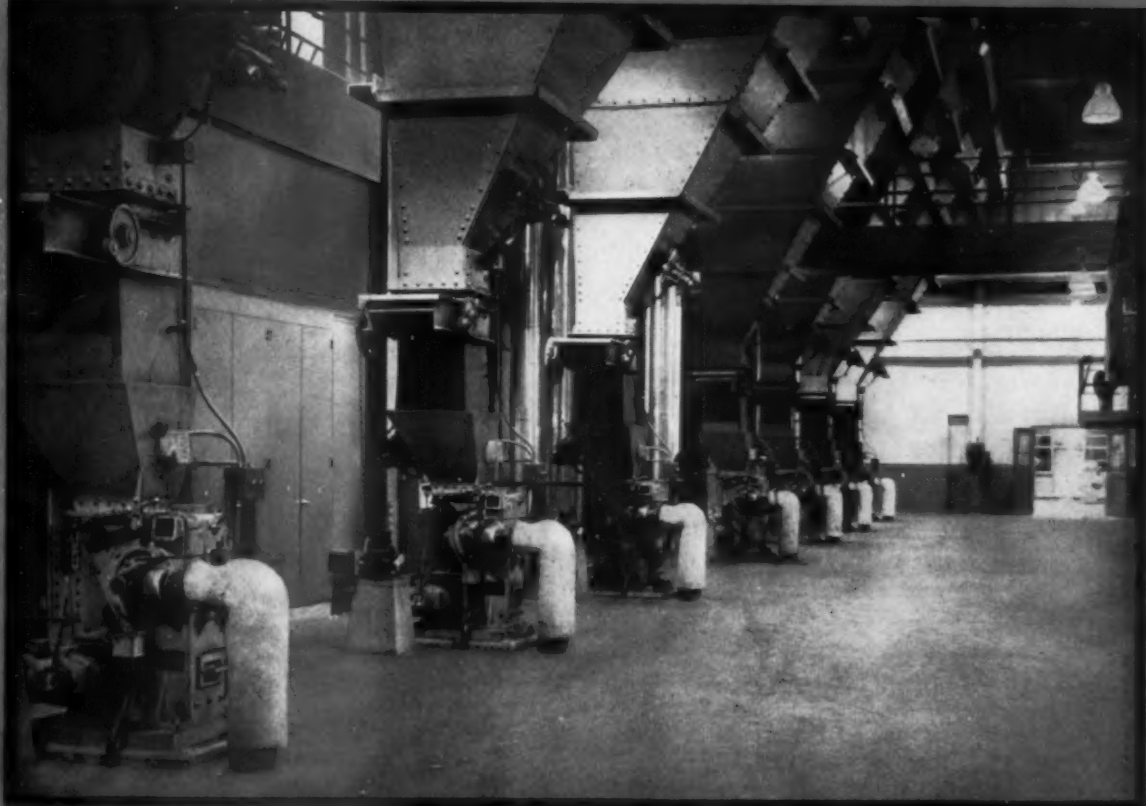

Photo by H. A. Bishop

Coal feeders at a recently completed eastern utility station

Caribou Steam Power Plant

Controlled Circulation Boilers for Utilities

Burning Coals from Northern Great Plains

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Feature Articles

Editorials

Departments

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COMBUSTION

Editorials

Fuel Engineering

It was apparent from various remarks during the recent Fuels Conference at Roanoke that there is need for more men trained in fuel technology to perform liaison between producers and consumers of coal. Although a few colleges give special attention to this subject, this is not widespread, and it is doubtful if many prospective graduates give serious consideration to the opportunities offered in this field.

More and more coal-producing companies are coming to realize the importance of closer contact with the problems of coal users, which have increased with decreased availability of premium coals, and some have established suitable setups for this purpose. This is of special significance in a highly competitive fuel market. Also, a number of the larger carriers have shown such interest particularly through service to the retailer.

The men selected to perform such work must have some knowledge of mining methods as related to coal characteristics; they must know the coals available in their districts; and have a rather intimate knowledge of combustion problems to the end that sound and discriminating advice may be offered in the matter of fuel selection. This applies particularly to servicing the smaller power plants which often do not possess much flexibility in the coal that can be burned efficiently and are seldom staffed with men having the requisite engineering knowledge. Without discounting the value of experience in carrying out such work, the importance of technical training is basic.

To those who might consider entering this field, it may be pointed out that it embraces opportunities not only with coal producers and coal-carrying railroads, but also with central stations and large industrial organizations and consulting firms, as well as in the field of research.

Chemical Cleaning of Boilers

At the Twelfth Annual Water Conference the session that brought forth the most enthusiastic discussion was concerned with chemical cleaning of boilers. Not very many years ago a proposal that acid be placed within the tubes of a steam generating unit would have aroused much suspicion because of the potential damage to metal surfaces. But today, under controlled conditions, chemical cleaning of many types of power plant equipment has become a common and accepted procedure.

Mechanical cleaning of boilers always has been a tedious job. With tube lengths on the larger units sometimes running in excess of 100 feet, it is almost impossible to obtain clean internal surfaces by mechanical methods alone. Where outage time is an important factor chemical cleaning has the distinct advantage of being much quicker. In most cases it is possible to use existing connections to the boiler to add and remove the cleaning solvent.

Careful supervision of chemical cleaning is necessary in order to protect personnel and to guard against damage to equipment. To date the safety record in cleaning boilers has been outstanding. It has been estimated that twenty-five cleanings may take place without appreciable loss of metal.

As is the case in any relatively new development, differences of opinion exist as to the best techniques. In any event the adoption of chemical cleaning of both new and serviced boilers by leading utility systems is evidence of its merit.

An Engineering Center

Although medical centers have been established in many sections of the country, combining educational work, widespread hospital facilities, and research, there has heretofore been little of a comparable nature in the field of engineering. As the first to meet this need, Columbia University has announced plans for the establishment of such a center in New York where undergraduate and graduate instruction, engineering practice, and research will be combined with the aim of developing "engineer-scientists." That is, it will include the present engineering school, an institute for advanced engineering science and a division of cooperative research which will work with industry on problems of educational value. The center also will work closely with the University's departments of pure science, social and political sciences and the humanities. Graduate students are expected to outnumber undergraduates.

A financial goal of over twenty-two million dollars has been set and a campaign has been launched to raise this amount.

It is most opportune that such plans be announced at present, not only because educational donations, within certain limits, are deductible from taxes, but particularly in view of the increasing demand for engineers with some scientific background. Such a center should do much to advance the prestige of the engineering profession. It is to be hoped that other similar centers may in time be established.

Caribou Steam Power Plant of The Maine Public Service Co.

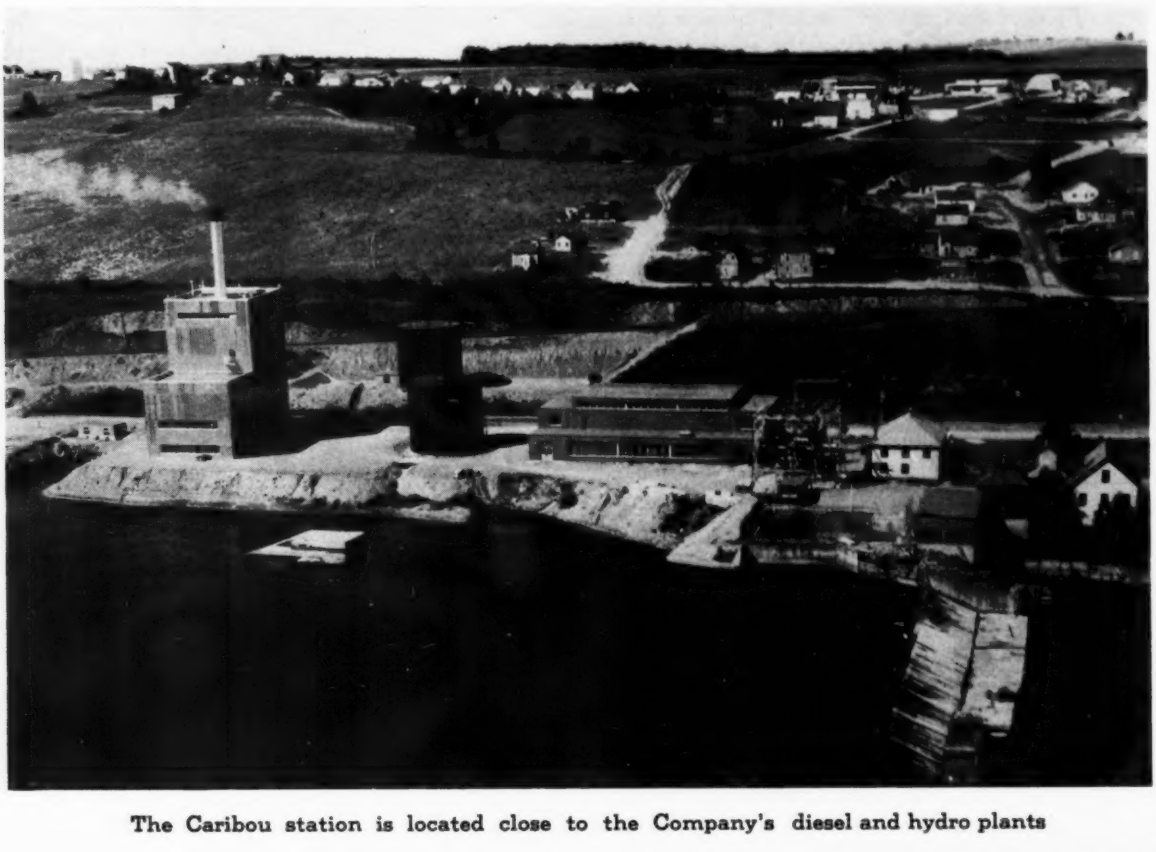
By EDWARD H. BARRY, Mech. Engr.
Stone & Webster Engineering Corporation

This 7500-kw, 600-psi, 825-F station supplements and is adjacent to the Company's diesel and hydro plants. Although burning oil at present, a spreader stoker and part of the coal-burning equipment are in place. In winter combustion air, taken from outside, is warmed by a steam-air preheater to minimize corrosion at the cold end of the gas-air preheater.

THE first steam-electric generating station of the Maine Public Service Company system has now been in commercial operation for about one year. Located at Caribou, Me., near the center of a rapidly expanding load, the station occupies a prominent position on the west bank of the Aroostook River, upstream of the Company's dam, at the outskirts of the town and alongside the line of the Bangor and Aroostook Railroad. The plant is adjacent to two other generating stations belonging to the same system, one a small hydro plant and the other a five-unit diesel-electric plant. A pumping and filter station of the local water company is also in the immediate vicinity. The juxtaposition of these plants makes for significant economies in management, maintenance and operation.

The Caribou station is designed on the unit system, with one 90,000-lb per hr steam generating unit and one turbine-generator rated at 7500 kw. Power is generated at 13.8 kv. Station auxiliaries are all motor-driven, normally taking their power from the generator leads. Auxiliary station service is obtained from the diesel plant bus via indoor service transformers. It is planned to extend the station in the future by the addition of one, and ultimately two, similar units.

Arrangement is on the "skyscraper" principle, thus utilizing to the best advantage the limited ground area. There is no basement. The station is entered on the ground level, at which grade are located the screen well, with traveling water screens and vertical circulating pumps; service-water, screen-wash and condensate

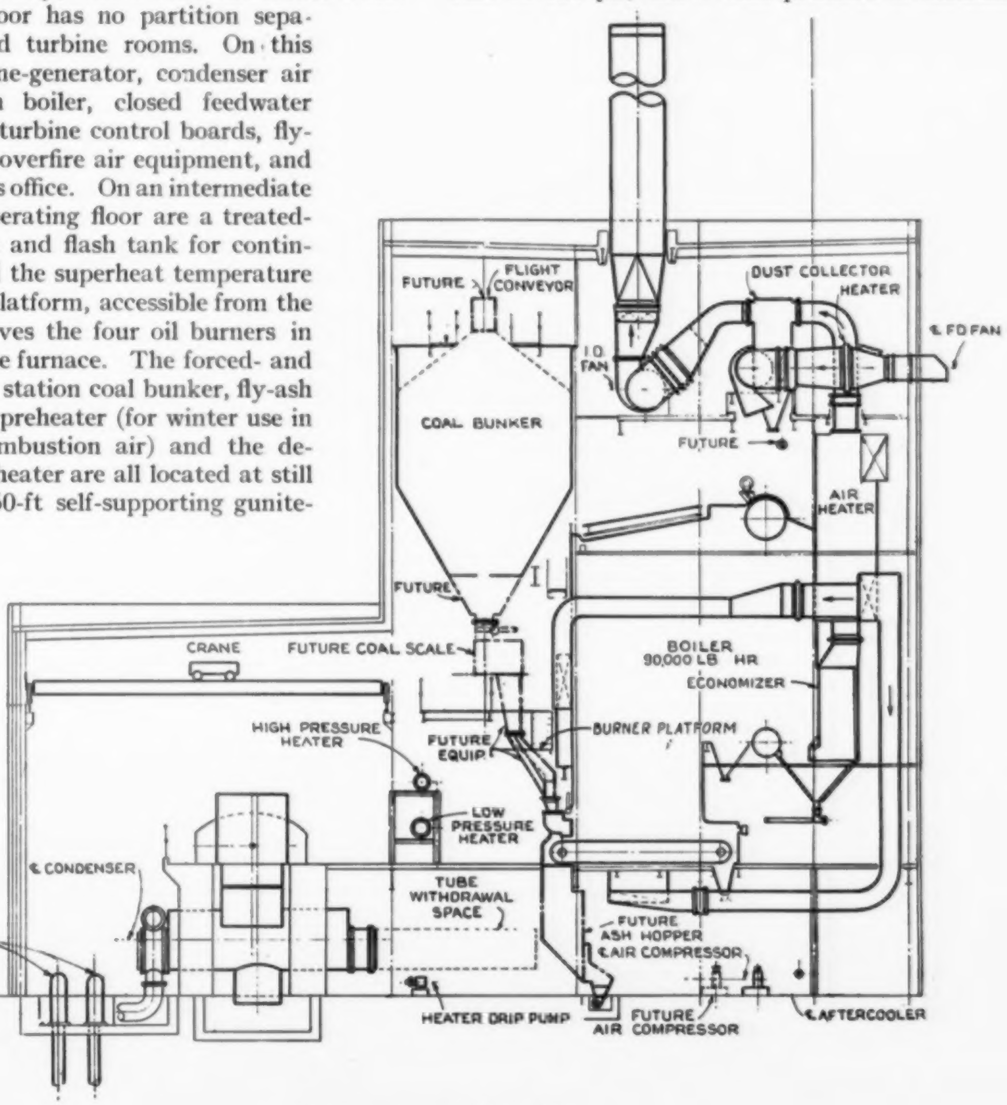


The Caribou station is located close to the Company's diesel and hydro plants

pumps; surface condenser; heating boiler; zeolite water softeners; boiler feed pumps; instrument air compressors; service substation; ignition fuel oil pump; boiler blowoff tank; furnace ash hopper; chemical feed equipment; heater drip pump; and a wash and locker room.

The operating floor has no partition separating the boiler and turbine rooms. On this level are the turbine-generator, condenser air ejectors, the main boiler, closed feedwater heaters, boiler and turbine control boards, fly-ash reinjection and overfire air equipment, and the superintendent's office. On an intermediate level above the operating floor are a treated-water storage tank and flash tank for continuous blowdown and the superheat temperature control panel. A platform, accessible from the operating floor, serves the four oil burners in the front wall of the furnace. The forced- and induced-draft fans, station coal bunker, fly-ash collector, steam air preheater (for winter use in heating outside combustion air) and the deaerating feedwater heater are all located at still higher levels. A 50-ft self-supporting gunite-lined stack is carried on the building roof. A small two-story wing on the south side of the building, presently used for stocking supplies and parts, is intended in the future for an ash storage and unloading system and as a garage for a bulldozer tractor. At the east side of the building is an open crane bay extending from ground floor to roof. This bay is equipped with a 15-ton traveling crane.

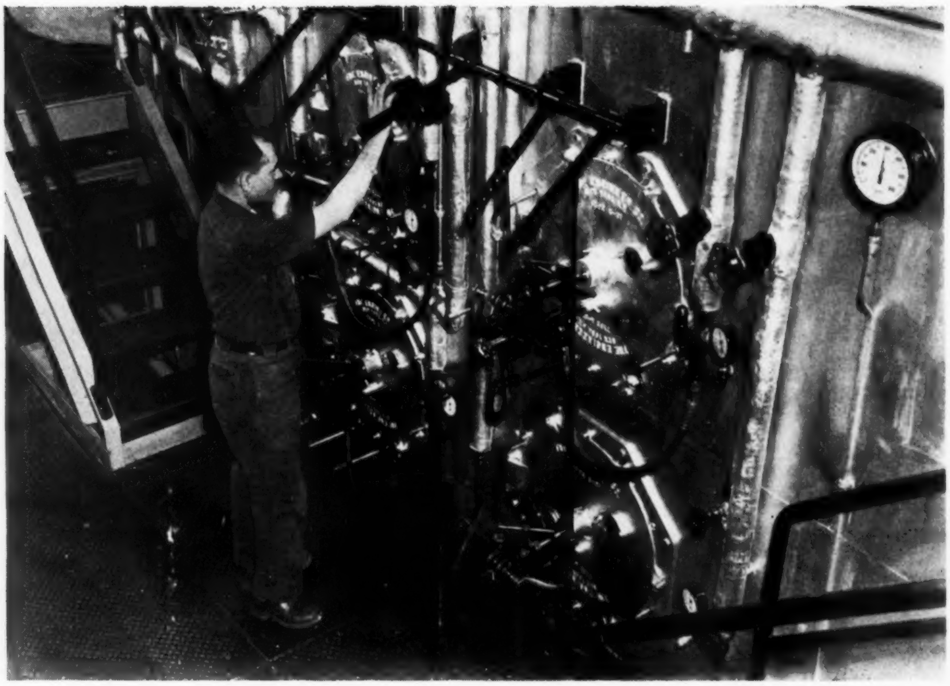
The steam generating unit is designed to burn either coal or Bunker "C" oil, but only oil-burning equipment has been completely installed. By the addition of a track coal hopper, coal-conveying, crushing and weighing equipment, and ash-conveying and unloading equipment, the station will be prepared to burn coal. The station coal bunker, spreader stoker and its auxiliaries and the fly-ash collector are already in place. The stoker grate has been covered with firebrick for its protection while burning oil.



Cross-section of the plant

Normal daytime load on the station is around 9000 kw, the corresponding steam generating rate being between 90,000 and 100,000 lb per hr, depending on the temperature of the cooling water. Steam is delivered to the turbine at 600 psi, 825 F and pressure is maintained by automatic combustion control, while the temperature is governed by a thermostatically controlled damper within the boiler setting. This damper diverts a portion of the gases around the superheater. Steam is conducted from the superheater outlet directly to the turbine. Since future boilers will not be in parallel, there is no need for a nonreturn valve at the superheater outlet. The feedwater system is similarly designed on the unit principle. Future units will have their own complement of boiler feed pumps. The present unit has two such pumps.

The steam generating unit consists of a two-drum bent-tube boiler with water-cooled furnace, superheater, economizer, tubular gas-air preheater; fly-ash collector; constant-speed forced- and induced-draft fans, each equipped with louver-controlled dampers; traveling grate spreader stoker, arranged to discharge the ash into a pit under the front of the furnace; four oil burners, with guns of the mechanically atomizing, variable orifice type,

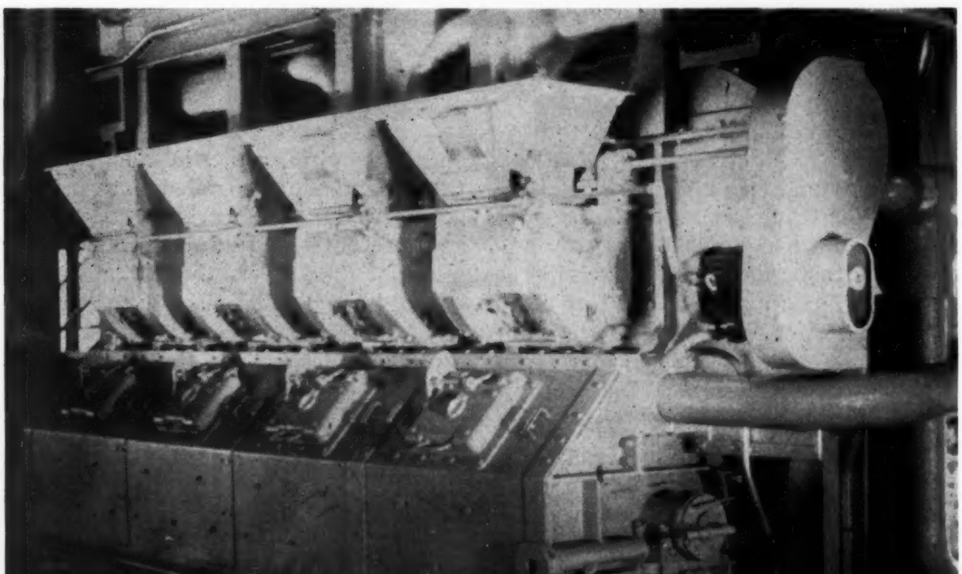


Burner platform showing wide-range mechanical-atomizing oil guns and automatic combustion control connections

utilizing oil at constant pressure; and auxiliary steam atomizing oil guns for use at light loads.

As mentioned previously, combustion air is taken from out-of-doors in winter, in order to avoid subatmospheric pressure within the building, when doors and windows are closed. The cold air is warmed by an auxiliary steam-air preheater, the purpose of which is to minimize the possibility of corroding the cold ends of tubes in the gas-air preheater. Steam to the auxiliary air heater is thermostatically controlled by the temperature of gases entering the stack. In summer, when the windows are open, the combustion air is taken from within the building, thus providing excellent ventilation.

Feedwater heating is accomplished in three stages of extraction heaters and by the flue gas economizer, the final temperature of the water entering the boiler being approximately 350 F. The first- and third-point heaters are of shell-and-tube type. The second-point heater is of the direct-contact, deaerating type with vent condenser and storage tank. Softened makeup is supplied to a treated water-storage tank through a level-control valve. This tank furnishes makeup to the condenser hotwell through a level-control valve at that point. The condensate pumps, located in a pit below the condenser, deliver the condensate makeup mixture from the condenser hotwell, through the inter- and after-condensers of the air ejection system, through the third-point extraction heater, through the vent condenser on top of the deaerator, then into the deaerating heater. Steam to the deaerator is taken from the second extraction point on the turbine. Drips from the third-point heater are pumped to the deaerator and those from the first-point heater are cascaded into the deaerator.

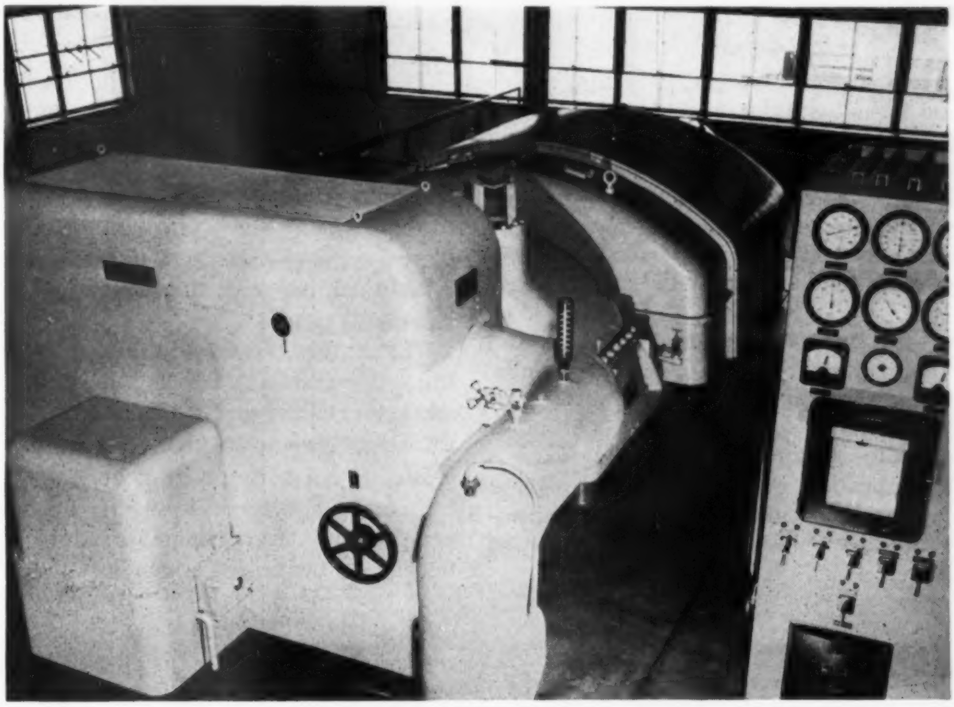


A four-unit spreader stoker has been installed to fire coal as a future alternate fuel

The turbine-generator is a four-bearing unit with a solid coupling between the turbine and generator. The generator is totally enclosed, with twin air coolers mounted inside the casing. The exciter is directly connected to the generator shaft. The complete unit is rated at 7500 kw, 13.8 kv, 9375 kva, 0.8 pf, 3-phase, 60-cycles, and is capable of developing full kva rating at unity power factor.

The turbine is of standard construction. The accessories include two auxiliary oil pumps, one steam-driven with automatic steam valve opening at a predetermined low bearing oil pressure, the other motor-driven, with manual starter, for use in case of an emergency shutdown due to failure of the boiler. The latter oil pump may also be used in connection with a turning gear, which, while not furnished initially, may be added in the future. The operating procedure used in starting and shutting down the unit has demonstrated that these operations can be performed satisfactorily without benefit of turning gear. The turbine is equipped with steam chest containing seven admission valves, which open in sequence, under control of the speed governor. Other accessories include an overspeed governor, automatic hydraulically opening spring-closing throttle valve, a similarly operating non-return valve in the second-point extraction line, and tripping devices which operate to shut down the unit in case of overspeed, low vacuum or low bearing oil pressure.

The condenser contains 7000 sq ft of $^7/_8$-in., 18-gage, admiralty metal tubes, 20 ft long. It is of two-pass design on the water side, with undivided water boxes, and is hung directly from the turbine exhaust flange. Circulating water is supplied by two vertical pumps submerged in the suction well, each of which is capable of supplying condenser cooling water requirements at somewhat more than one-half load on the turbine.



The 7500-kw turbine-generator

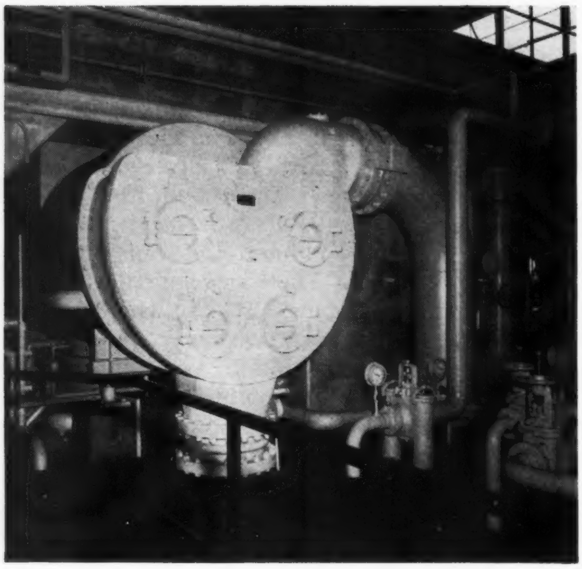
Circulating water orginates in an excavated inlet in the river bank, south of the station and above the Company's power dam. It enters the suction well through a 36-in. rack-protected intake buried about 25 ft below ground. Ahead of the intake is an electric fish screen, which is especially effective against eels. Warm condenser water is discharged downstream from the intake, but above the dam.

Both the forced- and induced-draft fans are equipped with double inlet boxes. These are required on the forced-draft fan because of the necessity of taking either inside or outside air, as mentioned previously.

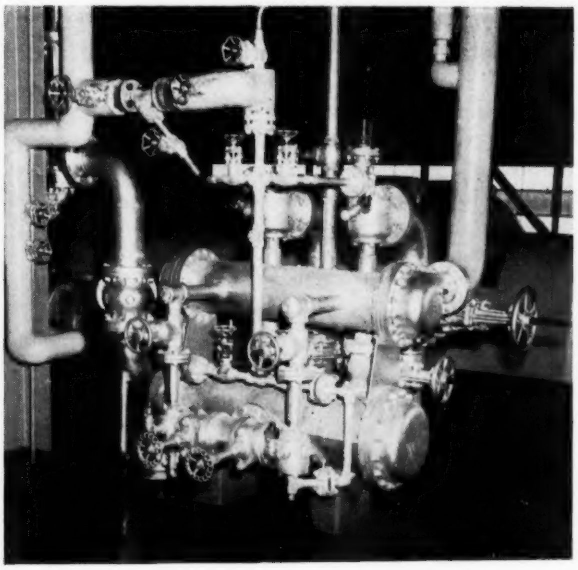
The feedwater system contains two motor-driven, 8-stage, centrifugal boiler feed pumps, driven by constant-speed induction motors. These pumps take suction from the storage portion of the deaerating heater. After passing through the first-point extraction heater, the feedwater enters the economizer through a 2-element feedwater regulator, responsive both to boiler drum level and to the steam output of the boiler.

Bunker C fuel oil is delivered to the plant either by railroad tank car or by tank truck, and heating steam is provided at the unloading station. The oil is pumped from the cars or trucks through an underground pipe assembly to a 10,000-bbl steel storage tank, located across the railroad tracks, and equipped with two vertical tubular steam heaters, as well as a horizontal tubular suction heater at the tank outlet. A small pump house adjacent to the storage tank contains the high-pressure rotary screw pumps for supplying the oil burners at the boiler. On its way to the burners the oil passes through steam fin-tube heaters, located in the oil unloading pump house on the station side of the tracks.

The turbine and boiler have control boards with a full complement of instruments and controls. On the turbine board are the usual instruments for guiding the operator



The 7000-sq ft two-pass surface condenser



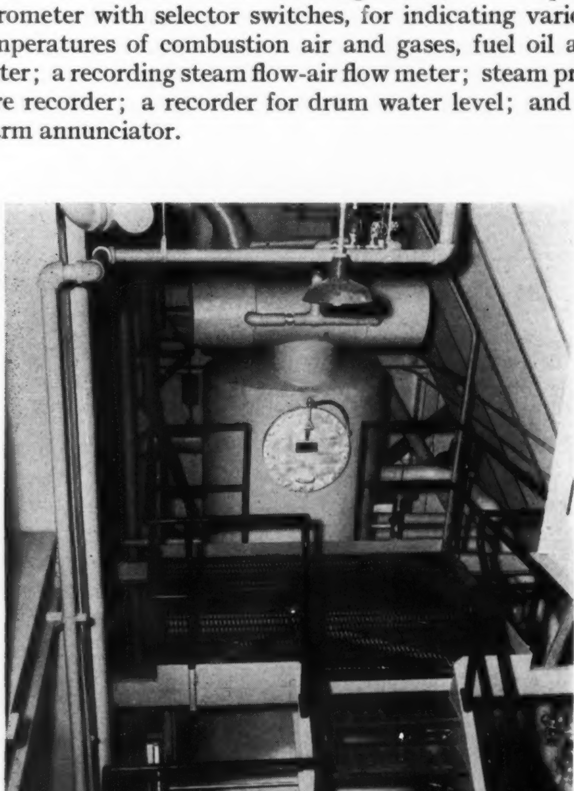
Closeup of twin two-stage ejectors

in synchronizing the generator, placing it on and taking it off the line, and for adjusting frequency and load. In addition, there are a mercurial barometer; vacuum gage; multipoint alarm-type pyrometer, for recording temperatures of generator cooling air and of individual stator coils; and the necessary indicating instruments, such as wattmeter, voltmeters, ammeter and synchroscope. The board also contains differential and other protective relays.

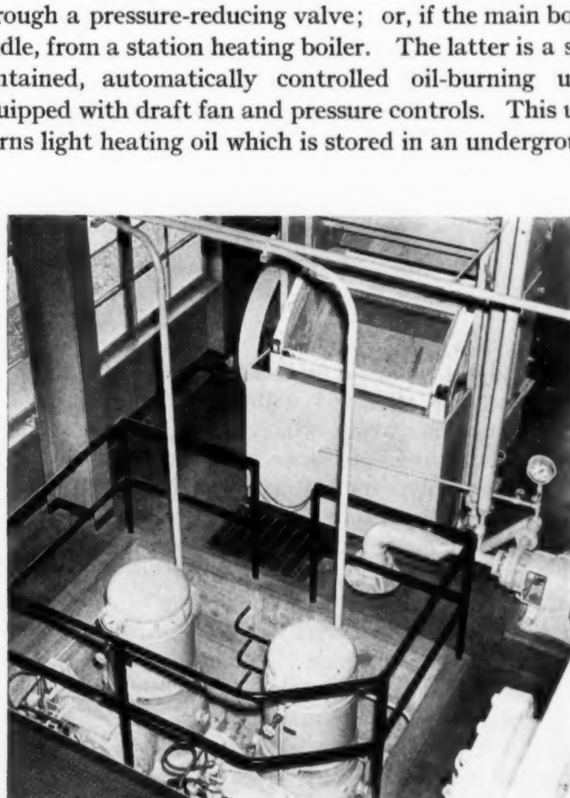
The boiler control board contains automatic and manual combustion control equipment; indicating pressure gages for steam, water and fuel oil; an indicator for water level in the deaerator storage tank; a multipoint pyrometer with selector switches, for indicating various temperatures of combustion air and gases, fuel oil and water; a recording steam flow-air flow meter; steam pressure recorder; a recorder for drum water level; and an alarm annunciator.

The combustion control equipment includes a draft regulator which operates the louver dampers at the inlets to the induced-draft fan; a master controller, which maintains the pressure of steam to the turbine by controlling and proportioning the flow of fuel oil and combustion air to the burners; and a purge interlock for preventing flow of fuel oil to the burners until furnace draft has been established and until the setting has been purged of inflammable gases.

The station is normally heated with steam extracted from the turbine. When that unit is idle, saturated steam for heating may be obtained directly from the boiler through a pressure-reducing valve; or, if the main boiler is idle, from a station heating boiler. The latter is a self-contained, automatically controlled oil-burning unit, equipped with draft fan and pressure controls. This unit burns light heating oil which is stored in an underground



Deaerating feedwater heater



Water screens and circulating pumps

tank outside the station. This same oil is also used in the main boiler during the start-up periods.

Electrical work includes the extension of an existing outdoor substation alongside the diesel plant by the addition of power transformers, high-tension circuit-breakers, disconnect switches, etc.; the installation of generator leads in underground conduit; indoor auxiliary unit substation with underground feeders from the 2400-volt diesel station bus; station lighting, both inside and outside; and a special intercommunication system between the ground, fan and operating floors of the plant.

Operating results have met expectations and no serious difficulties, due to severe subzero temperatures during the past winter, were encountered.

Stone & Webster Engineering Corporation designed and constructed the station, instructed the operators and assisted in placing the plant in commercial operation. It also acted as the Company's agents in purchasing and expediting all equipment and materials for construction.

PRINCIPAL EQUIPMENT OF CARIBOU STEAM POWER PLANT, MAINE PUBLIC SERVICE COMPANY

STEAM GENERATING EQUIPMENT

Boiler

Two-drum bent-tube type with water-cooled furnace; rated at 90,000 lb per hr, 600 psi, 825 F at superheater outlet. Furnace volume 5480 cu ft. Heating surfaces: Boiler, 7690 sq ft; water walls 1013 sq ft.—*Combustion Engineering-Superheater, Inc.*

Superheater

Elesco multiple-loop, pendant, convection type. Heating surface, 2820 sq ft.—*Combustion Engineering-Superheater, Inc.*

Economizer

Multiple-loop, fin tube and header type; 2070 sq ft heating surface.—*Combustion Engineering-Superheater, Inc.*

Air Preheater (gas)

Tubular type, single-pass on gas side. Heating surface, 6600 sq ft.—*Combustion Engineering-Superheater, Inc.*

Air Preheater (Steam)—*American Blower Corp.*

Soot Blowers—*Diamond Power Specialty Corp.*

Safety Valves

Consolidated Safety Valve Div., Manning, Maxwell & Moore, Inc.

Water Column and Gage Glasses

Diamond Power Specialty Corp.

Spreader Stoker

Combustion Engineering-Superheater, Inc.

Blowoff & Drain Valves

Edward Valves, Inc.

DRAFT SYSTEM

Forced-Draft Fan

No. 6 Sirocco, forward-curved blades, double inlet boxes.—*American Blower Corp.*
Motor drive, 60 hp, 860 rpm.—*Elliott Co.*

Induced-Draft Fan

No. 6 Sirocco, forward-curved blades, double inlet boxes.—*American Blower Corp.*
Motor drive, 150 hp, 1165 rpm.—*Elliott Co.*

Fly-Ash Collector

Mechanical type, No. 9VG12, size 80-5.—*Western Precipitation Corp.*

FEEDWATER EQUIPMENT

Boiler Feed Pumps

Two No. $2^1/_2$ RT8, 8-stage.—*Ingersoll-Rand Co.*
Motor drives, 200 hp.—*Elliott Co.*

Deaerating Heater

Tray type, with storage tank and vent condenser.—*Elliott Co.*

First-Point Extraction Heater

Horizontal, 2-pass, shell and tube, cupronickel tubes, 270 sq ft.—*A. O. Smith Corp.*

Third-Point Extraction Heater

Horizontal, 4-pass, shell and tube, B-111 copper tubes, 285 sq ft.—*Whitlock Manufacturing Co.*

Heater Drip Pump—*Worthington Pump and Machinery Corp.*

Zeolite Water Softeners—*Cochrane Corp.*

GENERATING EQUIPMENT

Turbine-Generator

7500 kw, 9375 kva, 0.8 pf, 3-phase, 60-cycle, 3600 rpm, with direct-connected exciter. Steam conditions, 600 psi, 825 F at throttle, 1.5-in. Hg exhaust, 3 extraction points.—*Elliott Co.*

CONDENSING EQUIPMENT

Surface Condenser

7000 sq ft, $^7/_8$ in., 18-gage Admiralty type B tubes, 2-pass, undivided water boxes.—*Elliott Co.*

Condensate Pumps

Two type 3GT, 2-stage—*Ingersoll-Rand Co.*
25-hp motor drives—*Elliott Co.*

Air Ejectors

Two 2-stage ejectors with inter- and after-condensers, one hogging jet.—*Elliott Co.*

Condenser Circulating Water Pumps.

Two vertical, submerged, type 20-H, single-stage.—*Peerless Pump Div., Food Machinery Corp.*
Motor drives, 40 hp.—*U. S. Electrical Motors, Inc.*

FUEL OIL EQUIPMENT

Fuel Oil Tank Heaters—*Brown Fintube Co.*

Fuel Oil Pumps—*De Laval Steam Turbine Co.*
Motor drives.—*Elliott Co.*

Fuel Oil Storage Tank

10,000 bbl.—*Chicago Bridge & Iron Co.*

Fuel Oil Suction Heater

Horizontal, fin-tube, 502 sq ft, 2-pass on steam side, single-pass on oil side.—*Griscom-Russell Co.*

Secondary Fuel Oil Heaters

Two 3-section, U-bend fin tubes.—*Griscom-Russell Co.*

Fuel-Oil Burners

Four wide range mechanical atomizing type, with variable orifice and constant oil pressure.—*The Engineer Co.*

MISCELLANEOUS EQUIPMENT

Raw-Water Booster Pumps—*Worthington Pump and Machinery Corp.*

Fabricated Piping—*National Valve & Mfg. Co.*

Steel Plate Work—*The Portland Co.*

Traveling Water Screen—*Chain Belt Co.*

Insulation—*The Insulation Co.*

Screen Wash Pump—*Worthington Pump and Machinery Corp.*

Instrument Air Compressors
Two 63-cfm displacement nonlubricated, class T-BO.—*Chicago Pneumatic Tool Co.*

Steam Heating Unit—*Superior Combustion Industries, Inc.*

INSTRUMENTS AND CONTROLS

Boiler Instruments
Draft gages.—*The Hays Corp.*
12-Point temperature indicator.—*Brown Instruments Div., Minneapolis-Honeywell Regulator Co.*
Boiler meter.—*Bailey Meter Co.*
Drum water level recorder.—*Bailey Meter Co.*
Deaerator water-level indicator—*Yarnall-Waring Co.*

Automatic Combustion Control—*Bailey Meter Co.*

Feed Water Regulator—*Bailey Meter Co.*

Miscellaneous Control Valves—*Fisher Governor Co.*

Circulating-Water Control Valves—*Henry Pratt Co., Inc.*

Miscellaneous Pressure Gages—*Crosby Steam Gage & Valve Co.*

Industrial Thermometers—*Taylor Instrument Co.*

ELECTRICAL EQUIPMENT

Auxiliary Unit Substation—*I-T-E Circuit Breaker Co.*

Generator Voltage Regulator—*General Electric Co.*

Control Boards—*G and N Engineering Co.*

Instruments—*General Electric Co.*

125-V Distribution Cabinet—*Westinghouse Electric Corp.*

Generator Field Circuit Breaker—*I-T-E Circuit Breaker Co.*

Generator Neutral Ground—*General Electric Co.*

CO_2 Fire Extinguishing System—*American Fire Equipment Co.*

Lighting Panel—*Westinghouse Electric Corp.*

Motor Controls—*Westinghouse Electric Corp.*

Generator Leads—*The Okonite Co.*

Power and Lighting Cable and Wire—*General Cable Corp.*

Lighting Transformers—*Westinghouse Electric Corp.*

Auxiliary Power Transformer—*Wagner Electric Corp.*

Instrument Transformers—*General Electric Co.*

Fuses, Fuse Disconnects, Switch Supports and Disconnect Switches—*General Electric Co.*

Conductor Supports—*Delta-Star Electric Co.*

Electric Fish Screen—*Electric Fish Screen Co*

Plant Intercom System—*Louis M. Herman Co.*

Controlled Circulation Boilers in the Utility Field

There are now building for eight well-known electric utilities in this country eighteen large, very high-pressure controlled-circulation steam generating units. These will serve an aggregate of approximately 2½ million kilowatts turbine-generator capacity. Features of controlled-circulation design are discussed.

THE fact that there are now building, or on order, eighteen large high-pressure steam generating units of the controlled-circulation type for nine central stations in this country is indicative of a marked trend in the electric utility field. These units, all ordered from Combustion Engineering-Superheater, Inc., within the last 15 months, range in rated output from 750,000 to 1,450,000 lb of steam per hour (100,000 to 200,000 kw) and in design pressures from 1670 to 2650 psig. All employ reheat of 1000 or 1050 F and initial steam temperatures run from 1000 to 1100 F. Each unit will serve a single turbine-generator.

A number of other units have been built, and are building, for the Naval service, but for obvious reasons little can be said concerning them at present.

Pertinent Features

In view of the foregoing it may be pertinent to review briefly certain features of this type of steam generating unit that render it especially adapted to such applications. In doing so the reader is reminded of the difference between a once-through forced-circulation boiler, such as the Sulzer and Benson types, in which circulation is produced by the feed pump forcing water through the steam generating circuits at a velocity proportional to the load; and the controlled-circulation type in which circulation is produced by a separate pump running at constant speed and entirely independent of the feed. Only a portion of the water circulated by this pump is evaporated into steam, the balance being recirculated. Yet the circulation ratio of water to steam is considerably less than that in a natural-circulation boiler.

A most important feature of this latter type, which is responsible for the designation "controlled circulation," is the employment of orifices to regulate the admission of water to the various heating circuits. These, aided by the flow resistance provided by the small-diameter tubes, afford close control of water distribution. Moreover, the resistance produced by the orifices is independent of thermal conditions in the furnace.

Both the once-through and the controlled-circulation types have been employed extensively abroad, although in units of lesser capacity. Some ten years' experience and exhaustive tests with the pioneer 2000-psi, 650,000-lb per hr C-E unit, installed under direction of Stone & Webster as consulting engineers, at Somerset Station of the Montaup Electric Company;[1] eight years with a high-makeup unit installed in 1943 at the Koppers synthetic rubber plant in Kobuta, Pa.; and seven years with large Naval units have been productive of much additional design and operating information which has resulted in refinements in design and established the advantages of controlled circulation for high-pressure service.

Since present practice among electric utilities points toward very large units of higher and higher steam pressure, it is logical that such units should be looked upon with increasing favor, as shown by the number now building, on order and under consideration.

With natural circulation it is the difference between the weight of water in the downtakes and that of the mixture of steam and water in the risers that produces circulation. However, since there is a very great increase in steam density and a marked decrease in water density at high pressures, this difference becomes less as the pressure increases. On the other hand, with controlled circulation not only is the head positively augmented by the pump but there is wide latitude in the arrangement and location of the heat-absorbing surfaces and drum. Downtake temperatures are lower and there is no steam entrapped in them. The lower water–steam ratio allows all risers to enter the drum generally in two rows, which permits welded nozzles and reduced drum thickness with consequent saving in drum weight.

Small Tubes Reduce Thermal Stress

Employment of a circulating pump permits the use of small-diameter ($1^1/_4$, $1^1/_2$ and $1^5/_8$ in.) thin-wall tubes. For the same hot-face temperature these thin walls have nearly double the permissible heat absorption of the conventional natural-circulation tubes, which have approximately twice the wall thickness. However, since other considerations dictate that furnaces of both types of units be about the same size, with little difference in heat absorption per square foot of radiant surface, the small-diameter, thin-wall tubes offer a *real* factor of safety against undesirable thermal stress which is about half that present with the larger thick-wall tubes. This is most important at high pressures.

The pump, by providing forced circulation in starting, permits rapid pickup of heat by the water in all parts of the boiler, which equalizes stresses and thereby allows the unit to be brought up to operating conditions in minimum time, within superheater and reheater limita-

[1] Operating experience with this unit was fully reported in a group of papers by representatives of the utility, the consulting engineers and the manufacturer at a symposium held during the ASME Annual Meeting, November 26–29, 1945.

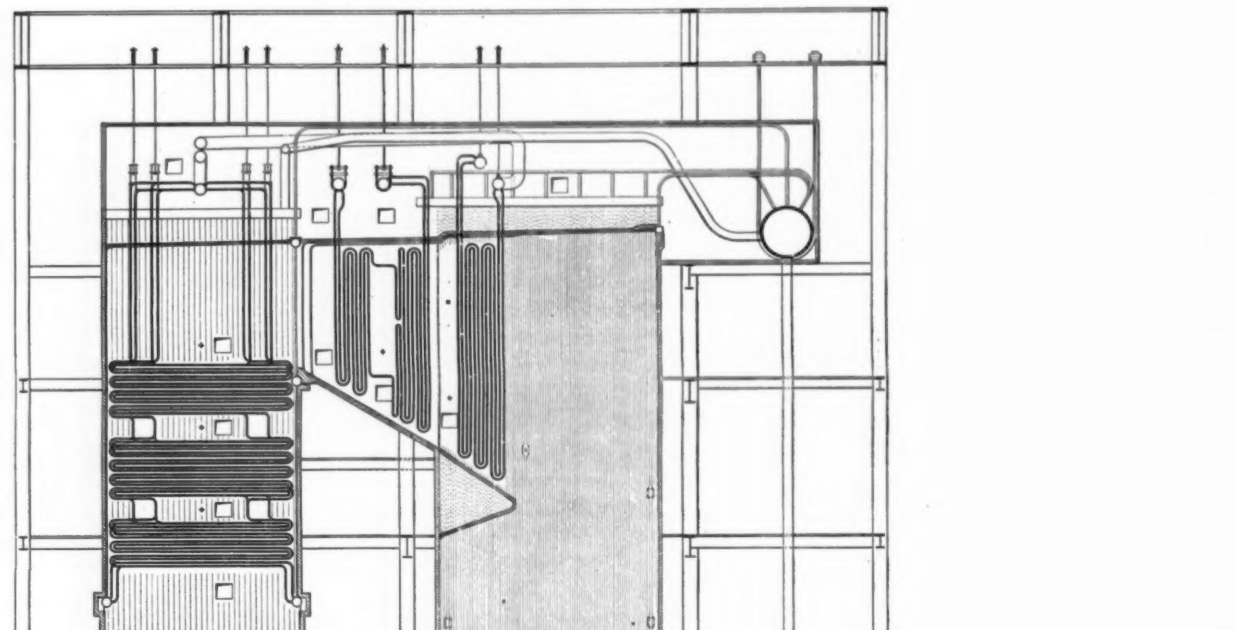
Although not directly related to the controlled circulation feature of this boiler, it may be mentioned that, despite a guarantee of less than $^1/_2$ ppm of solids in steam which was fully met, the small carryover was responsible for the high-pressure turbine gradually losing capacity to the extent that periodic washing of the blades became necessary. However, since the later substitution of new drum internals, no turbine deposits have been indicated. While the type of new drum internals employed will insure equally clean steam in a natural circulation boiler, a smaller number of separators is required with controlled circulation, as less attention need be given to pressure drop.

tions, with some saving in fuel. Furthermore, when the unit is banked one of the circulating pumps may be operated at low speed to maintain equal temperatures throughout. This may be likened in principle to the well-known turbine turning gear. Conversely, less time is required when shutting down, and since there is less water in the unit, time is saved in draining. This is in contrast to the conventional boiler which has no circulation in starting and in which subsequent circulation varies with output and pressure.

The weight of pressure parts (exclusive of the superheater) in a boiler of the controlled-circulation type is about half that for a natural-circulation boiler of like capacity, which should be a factor under the present materials situation. All pressure joints are welded and the absence of rolled joints avoids the danger of acid or caustic attack at these locations. Handhole caps and gaskets are eliminated.

In general, the large units are provided with three circulating pumps, one of which is a spare. These are of the vertical-shaft type, suspended between the suction gate valves and the discharge nozzles. Pump foundations are thus eliminated and free expansion is permitted. Precision-made mechanical seals practically eliminate leakage. The pumps operate only on the differential pressure necessary to overcome the resistance of the tubes.

Operating experience has shown that, after the initial chemical cleaning for mill scale, subsequent cleaning is comparable with that of a natural-circulation unit. Also,



Section through typical large high-pressure Combustion Engineering controlled-circulation unit

because the water velocity does not vary with load, the water level in the drum has been found to be exceptionally steady, even under rapid load swings of considerable magnitude.

In the matter of safety, a tube rupture is much less serious than in a natural-circulation boiler and immediate shutdown is unlikely. In fact, with one large high-pressure controlled-circulation unit it was found possible to operate for several days with water issuing from a ruptured tube. When shutting down for such reason, not only can the boiler be cooled down in less than half the time required for a natural-circulation unit, but the repair of a small tube requires very much less time than that needed for welding in a section of 3-in. tube. Thus, the total outage is greatly reduced.

Other features might be mentioned and discussed in greater detail, but it is believed the foregoing will suffice to bring the reader up to date on some of the reasons that account for the favorable reception accorded the controlled-circulation design for large high-pressure utility service.

The following well-known electric utilities now have controlled-circulation units on order, ranging from 750,000 to 1,450,000 lb of steam per hour, with the turbines served ranging from 100,000 to 200,000 kw. The design pressures range up to 2650 psi and the steam temperatures up to 1100 F. All will employ the reheat cycle:

Virginia Electric & Power Co.
Duke Power Co.
Wisconsin Electric Power Co.
Southern California Edison Co.
Cleveland Electric Illuminating Co.
Public Service Electric & Gas Co. (New Jersey)
Philadelphia Electric Co.
Consumers Power Co.

A CORRECTION

Inadvertently, the photograph on the cover of October Combustion carried the wrong caption. It should have been "Palatka Steam-Electric Generating Station of the Florida Power & Light Company," instead of "New Suwanee River Plant of the Florida Power Corporation," construction of which was only recently begun.

Facts and Figures

Production of crude oil in the United States has now passed six million barrels per day.

•

Electric utilities consume over 21 per cent of the bituminous coal mined.

•

A new oil well is brought in, on the average, every 21 minutes in the United States.

•

Any surface at a temperature above 700 F will ignite most combustible materials in contact with it.

•

Free nations of the world have a three-to-one advantage in coal reserves over Communist-dominated countries.

•

One pound of uranium 235, in energy liberated, is equivalent to that liberated by burning 1,700,000 lb of gasoline.

•

Bituminous coal production thus far this year is about 30 million tons ahead of that for the same period last year.

•

Investigations indicate that sulfur is the chief controlling factor in the formation of hard bonded deposits on the gas side of heat absorbing surfaces of a boiler.

•

More than 200 educational institutions are engaged in research and development phases of the atomic energy program.

•

According to the Bituminous Coal Institute, in the coking process a ton of coal yields about 1400 lb of coke, 10,000 cu ft of fuel gas, 8 gal of tar, and almost 3 gal of light oil, in addition to sulfate of ammonia.

•

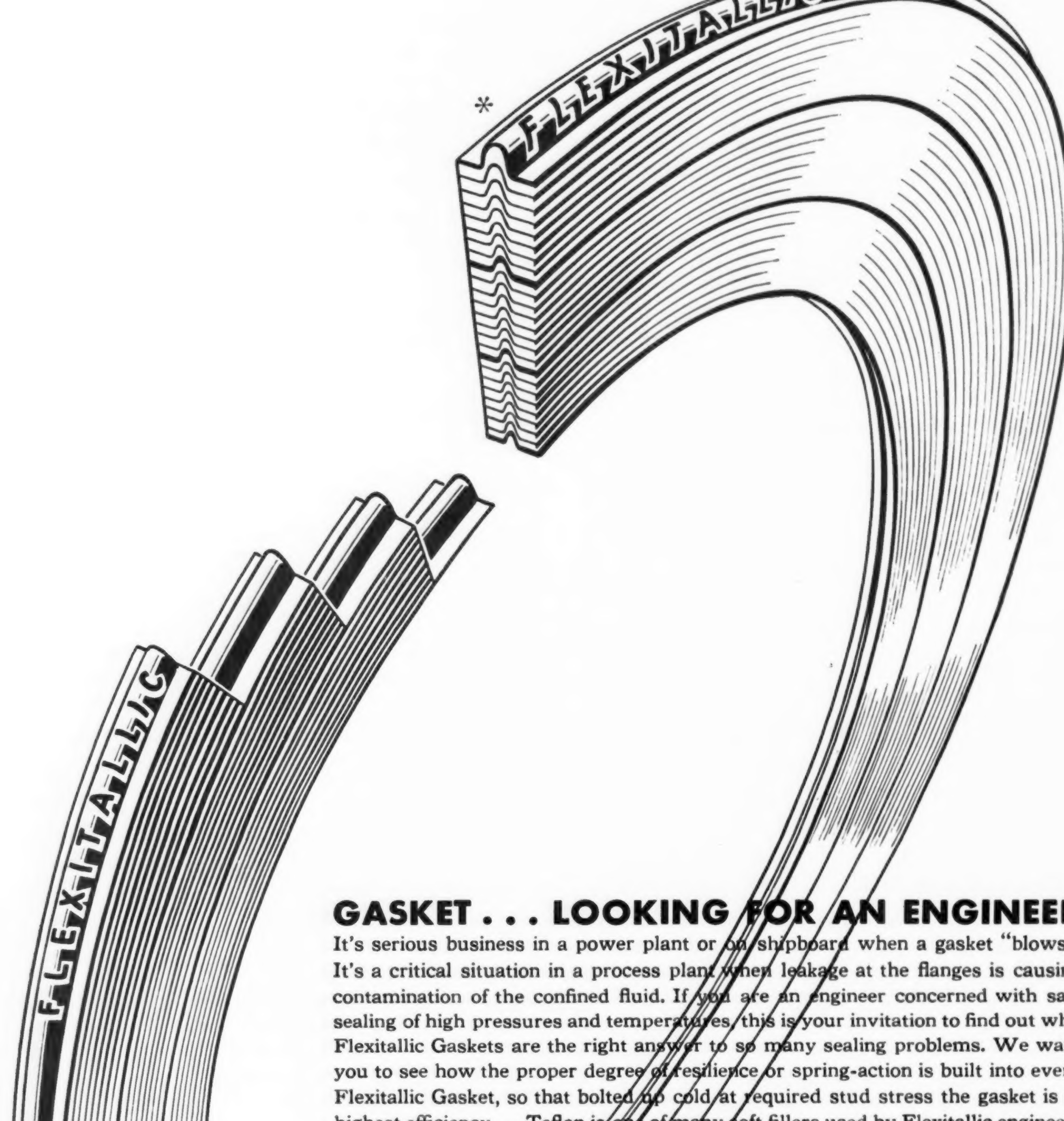
Mineral wool, much used for insulation, is prepared by melting slag at high temperature and then pouring it in a thin stream over a high velocity steam nozzle that blows the molten mass against a metal screen.

•

If electric utility steam plants were operating at 1920 efficiency standards, they would consume about 300 million tons of coal during 1951 instead of approximately 100 million tons, which figure is indicated by the present rate of consumption.

•

Periodic inspection of overfire jets is important to make sure that the ends of the nozzles are free of slag accumulations.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Burning Coals from the Northern Great Plains Province

By JOHN H. CRUISE* and OTTO DE LORENZI†

Combustion Engineering-Superheater, Inc.

Excerpts from a paper presented at the ASME Fall Meeting in Minneapolis, September 26–28, in which the authors review experience in burning these fuels, particularly lignite, on underfeed, traveling grate and spreader stokers, as well as in pulverized form, and discuss furnace designs best adapted to such use.

THE U. S. Geological Survey has divided the coal-bearing areas of this country into six main provinces designated as: (1) Eastern, (2) Interior, (3) Gulf, (4) Northern Great Plains, (5) Rocky Mountain and (6) Pacific Coast.

The Northern Great Plains Province includes all the coal fields of the great plains east of the eastern front range of the Rocky Mountains. Here are immense lignite areas of the two Dakotas, and the bituminous and subbituminous fields of northern Wyoming and northern and eastern Montana. These deposits also extend into the Canadian Provinces of Alberta, Manitoba and Saskatchewan. With but few exceptions the coals are all of low rank. Many kinds and shades of transition from one coal to another are found in the various provinces, and are broadly classified as: lignite, subbituminous, bituminous and anthracite.

The origin of coal is vegetal matter. Thus the transformation, through wood and peat to lignite and finally anthracite, results in a reduction of volatile matter and oxygen content, together with a simultaneous increase in carbon content. This is illustrated in Fig. 1 from which it will be noted that the Dakota and Texas lignites are closely related and not far removed from the subbituminous coals of Wyoming. Likewise Souris lignite from Saskatchewan is an extension of the Dakota deposits and therefore almost identical in all characteristics. Inasmuch as all these coals are of low-rank and non-agglomerating (free-burning), weathering types, the problems of preparing, handling and burning are somewhat similar.

Underfeed Stokers

The underfeed stoker is seldom used for lignite and subbituminous installations. This is because the underfeed type of fuel bed requires agitation and is relatively thick, so that comparatively high air pressures are needed. Non-agglomerating (free-burning) fuels do not readily hold together and are therefore liable to drift under the combined influences of air pressure and fuel-bed motion, particularly if high burning rates are used. Furthermore, the weathering characteristic of lignite results in severe size degradation by splintering and shattering as the moisture is quickly driven off under furnace operating conditions, and this in turn produces carryover of char and fly ash.

Even though the subbituminous and lignite fuels are not particularly well suited to underfeed firing, there have been a number of satisfactory installations.

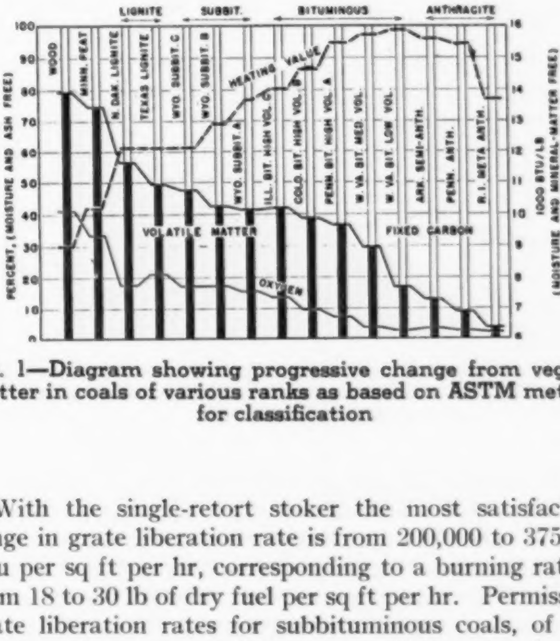

Fig. 1—Diagram showing progressive change from vegetal matter in coals of various ranks as based on ASTM method for classification

With the single-retort stoker the most satisfactory range in grate liberation rate is from 200,000 to 375,000 Btu per sq ft per hr, corresponding to a burning rate of from 18 to 30 lb of dry fuel per sq ft per hr. Permissible grate liberation rates for subbituminous coals, of this area, are between 5 and 10 per cent higher than for lignite.

Industrial types of single-retort stokers have grate areas which range from 12 to 125 sq ft. They may therefor be used for steam capacities up to 30,000 lb per hr. The furnace usually comprises vertical refractory walls, and as no ignition or combustion arches are required, much of the heat in the fuel bed is transferred to the boiler surfaces by radiation. For satisfactory operating conditions the furnace heat-liberation rate should be below 40,000 Btu per cu ft per hr.

When larger units having capacities up to approximately 200,000 lb of steam per hour are required, it is possible to use the multiple-retort stoker. The furnace is also of the simple type, using vertical refractory front

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and side walls and water-cooled rear wall. Liberation rates are preferably held below 35,000 Btu per cu ft per hr. Air preheaters should be used if their installation costs can be justified. Preheated air temperatures should be limited to not more than 325 F.

Fuel size is important with underfeed stokers. The usual preferred specification is 1[1]/[2] in. by 0 in. In many

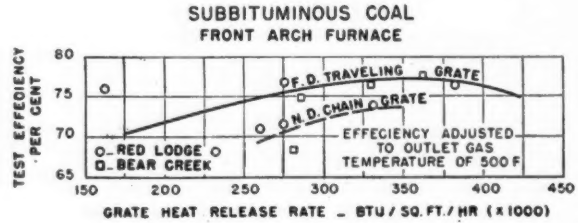


Fig. 2—Performance curves for natural-draft chain-grate and forced-draft traveling-grate stokers, with front-arch furnaces, when burning subbituminous coals from Montana and Wyoming

instances, however, improved operation has resulted where 1[1]/[4]-in. by [1]/[4]-in. double screen coal is used.

Chain- and Traveling-grate Stokers

Chain- and traveling-grate stokers provide a continuously moving, non-agitating type of grate surface whereby fuel is supplied to the furnace in a level, uniformly thin bed and the refuse is continuously and automatically discharged to the ash pit. Prompt and rapid penetration of ignition is necessary for efficient operation. This is obtained through the use of arches which reflect heat, or direct the hot gas stream, onto the surface of the incoming green fuel. The intensity of reflected heat will govern the speed at which it is possible to move the grate through the furnace.

All types of free-burning fuels, including those having high moisture content and severe weathering characteristics, are best burned where the fuel bed is left undisturbed. The weathering which occurs in low-rank fuels results in fuel beds containing high percentages of undersize. Fly-ash carryover and ash-pit loss will be excessive,

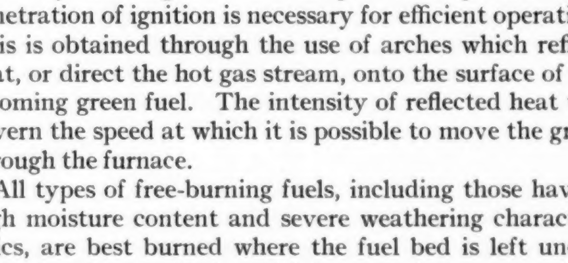


Fig. 3—Performance curves for natural-draft chain-grate stoker and forced-draft traveling-grate stoker burning lignite

even though combustion rates may be low, unless suitable provisions are made to retain the maximum quantity of these fines in the furnace.

The earlier designs of chain-grate stokers were of the natural-draft type with front arches. Stokers of this type were widely used until about 1922, and many installations are still in operation. Their performance, however, does not equal that obtainable with more modern designs.

Test performance of natural-draft stokers with subbituminous coal and lignite is shown in Figs. 2 and 3.

From 1919 to 1925 there were many new and simultaneous developments in fuel-burning, steam-generating and heat-recovery equipment applications. Of special interest here are: the first really successful installation of a forced-draft traveling-grate stoker to burn midwestern bituminous coal in 1919; development of a rear-arch type furnace for small size anthracite, in 1920; an air preheater installation in 1922; and water-cooled furnace walls in 1923. The combination of all these provides the highly efficient, modern steam generating unit that performs so satisfactorily on subbituminous coal and lignite.

The first steps in the development of this modern unit came during 1922 with the installation of forced-draft traveling-grate stokers in the boiler plants of the Uni-

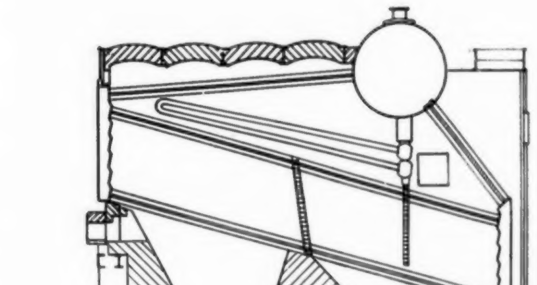


Fig. 4—Combination-arch furnace with forced-draft traveling-grate stoker installed at Mobridge, S. Dak., in 1928

versity of Montana at Missoula and the Northern Pacific Railroad Co. at Laurel, Mont. These were followed in 1925 by a similar installation in the heating plant of the Missoula Public Service Corp. The units were all provided with front-arch type furnaces and burned Red Lodge No. 5 and Bear Creek [3]/[4]-in. slack. Results of tests on these three installations are shown by the upper (full line) curve in Fig. 2. It will be noted that a higher efficiency along with a wider capacity range, as contrasted with the natural-draft type, was available for this newer forced-draft design.

Efforts to burn lignite on the forced-draft stoker installed in a front-arch furnace did not prove to be very successful. Consequently it was suggested that the rear-arch or perhaps a combination of front-and rear-arch be tried. An installation of this type was made for the Northern Power and Light Co. at Mobridge, South Dakota, during 1928. Two identical boilers were used: the first equipped with a forced-draft traveling-grate stoker set in a combination arch furnace as shown in

Fig. 4; the second was the same in all respects as the first except a rear-arch furnace, Fig. 5, was used. An air heater was provided for each unit. Results of tests on these two units are shown by the solid line curves in Fig. 3. It will be noted that practically no efficiency difference exists below a grate liberation rate of approximately 275,000 Btu per sq ft per hr, but above this the effect of the rear-arch is to increase the efficiency level at 350,000 Btu per sq ft per hr by over 10 per cent. This difference is due primarily to the improved fuel bed conditions because of prompt and speedy ignition as well as because of the more turbulent flow of gas in the furnace, which in turn promotes rapid drying of the incoming wet fuel, eliminates stratification by thoroughly mixing rich and lean gas so that burning may be completed promptly, and also returns a large portion of ignited flying char to the fuel bed.

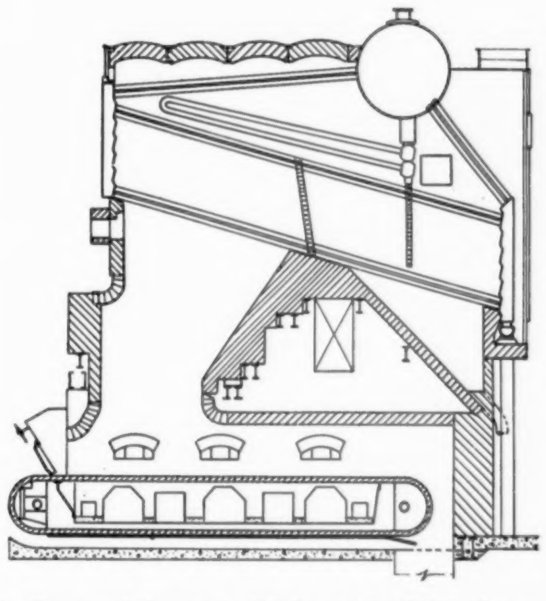


Fig. 5—Rear-arch furnace with forced-draft traveling-grate stoker installed at Mobridge, S. Dak., in 1928

With the Mobridge tests as a basis, two installations were next made for burning Texas lignite, one at the University of Texas and the other at the A. and M. College of Texas. Refractory furnaces were used, but the rear arch was set somewhat lower and also lengthened. By doing this the gas velocity and resulting turbulence was stepped up. A watercooled side-wall clinker-chill was provided to avoid ash adhesion to refractory walls, thereby eliminating fuel bed disturbance. A plate-type preheater was used to furnish 325 F air for combustion.

The results of tests on these units, made during the off-peak heating season, are also shown in Fig. 3 at the low heat-release-rate end of the upper (dash-dot) curve. The University of Texas installation has operated at grate heat release rates of 450,000 Btu per sq ft per hr without difficulty and with lignite containing 35 per cent moisture.

We now come to the latest rear-arch type of steam generating unit which has incorporated in its design the proved features from previous experiences. In 1946 the Saskatchewan Power Commission contracted for a unit to be installed in its Estevan Steam Plant. The fuel was Souris lignite bug dust, rejects from a double-screening operation to produce suitable size consist for other stoker types. The two-drum type steam-generator with traveling-grate stoker set in a rear-arch furnace, shown in Fig. 6, was designed for a maximum capacity of 80,000 lb of steam per hour. The long, low arch is of the water-cooled refractory type, and the furnace front wall is completely water-cooled with fin tubes, but has a refractory covering over the lower 15 per cent. Furnace roof and sidewalls are partially cooled by spaced plain tubes and there is a water-cooled clinker chill at the grate line. Air for combustion, both below the grate and overfire, is preheated to 320 F.

It was found that this unit could be easily operated at rates in excess of guarantees. The results of a test at 86,000 lb of steam per hour showed an efficiency of 73.7 per cent, adjusted to 500 F exit gas temperature, with a corresponding grate liberation rate of 336,000 Btu per sq ft per hr. The capacity was limited by the induced-draft fan. The stoker speed was approximately 80 ft per hr and fuel bed thickness $4^{1}/_{4}$ in.

As a result of the test investigations it was decided to remove the covering over the rear-arch water-cooling tubes. Inasmuch as these tubes are on 7-in. centers, approximately 50 per cent of the arch now became an area capable of absorbing heat at high rates through radiation and convection transfer. The refractories covering the lower end of the first wall tubes were also removed. These changes in no way impaired ignition.

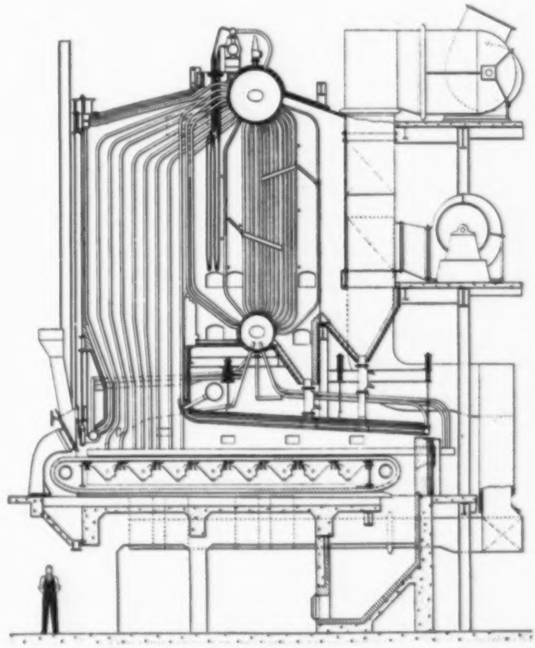


Fig. 6—Water-cooled rear-arch furnaces with traveling-grate stokers installed at the Estevan Steam Plant in 1946 and 1949

Based on this experience, a duplicate unit was ordered in 1949, the only modification being an increase in the sizes of both forced- and induced-draft fans to permit a continuous capacity of 100,000 lb of steam per hr. This newer unit has now been in satisfactory operation for

some time. Grate speeds of 100 ft per hr have been used without any sign of darkened areas or impaired ignition. Capacities up to 110,000 lb per hr have been reached without difficulty, and the corresponding efficiency, adjusted to 500 F outlet gas temperature, is 72 per cent at a grate liberation rate of 380,000 Btu per sq ft per hour.

The superior performance of the Estevan units has clearly demonstrated that where traveling-grate stokers are used the rear-arch furnace will assure most satisfactory operation with low-rank fuel. The fully ignited and active fuel bed contrasts sharply with the darkened front drying zone so typical of the combination-arch furnace.

Traveling-grate stokers for rear-arch installation are available in sizes from 4 ft 0 in. to 26 ft 6 in. in width and from 12 ft 0 in. to 28 ft 0 in. in length. The maximum continuous grate liberation rate is limited, for the present, to approximately 400,000 Btu per sq ft per hr, and the furnace liberation rate to 40,000 Btu per cu ft per hr. On this basis it is possible to build a unit similar to Estevan having a continuous output of 200,000 lb of steam per hr, when burning a $^3/_4$ in. by 0 in. North Dakota, Texas or Saskatchewan lignite with a moisture content of from 35 to 40 per cent.

Spreader Stokers

The spreader stoker employs the combined principles of suspension burning of the fine fuel in the furnace cavity and in-position of the larger sizes on a non-agitating grate which may be of the dumping or the continuous-discharge type. Fresh fuel is continuously projected into the furnace above that which is burning on the grate. The fines, consequently, are quickly ignited and burn in suspension, in the upper furnace zone The larger particles are exposed to the full effect of furnace temperature as they fall onto the fuel bed. Moisture and volatile matter are quickly driven off, and the tendency to coalesce is almost entirely destroyed.

With lignite and subbituminous coal, because of extreme weathering characteristics, size consist is of considerable importance. The shattering and splintering in the furnace atmosphere mean a larger proportion of fuel is burned in suspension. Consequently, dust loading of the gas entering the boiler is higher than where agglomerating coals are burned. In addition, because of lower heat content there is the necessity for using larger quantities of fuel. These factors, therefore, are responsible for the use in some areas of a double-screened fuel. By rejecting all the fuel below a given size, it becomes possible to minimize fly ash and char carryover from the furnace, as well as the chimney. For installation in the Dakotas and Minnesota the screen size is usually $1^1/_4$ in. by 0 in. Where Sheridan (Wyo.) lignite is used, the fuel size is frequently $^3/_4$ in. by 0 in.

With conventional spreader stokers, burning lignite or subbituminous coal, the preferred continuous grate liberation rate should not exceed 500,000 to 550,000 Btu per sq ft per hour. When large continuous-ash-discharge types are used, this rate may, at times, be increased to 650,000 Btu per sq ft. Furnace liberation rates should preferably not exceed 30,000 Btu per cu ft per hr even though complete water cooling of the walls is provided.

The choice between dump-grate and continuous-ash-discharge types is usually dictated by size of unit, ash content of fuel and economics based on plant operating conditions. Inasmuch as continuous-discharge stokers are usually installed with comparatively large steam-generating units and also require no fuel-bed disturbances for ash removal, their operating conditions are more favorable than those of the dump-grate types. This difference, shown in Fig. 7, is reflected by an efficiency increase over the entire operating range.

The characteristic shattering and splintering which occur in the furnace cavity above the fuel bed when spreader firing these low-rank fuels result in a high dust loading of the furnace gas. This dust is fine and has a

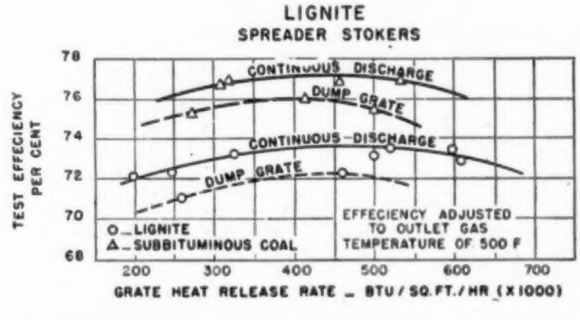


Fig. 7—Performance curves for dump-grate and continuous-ash-discharge types spreader stokers burning subbituminous coal and lignite

relatively high fusion temperature so that very little actual slagging occurs. A considerable quantity, however, is deposited on the heat-absorbing surfaces, to which it clings tenaciously. Inasmuch as these dust deposits may accumulate rapidly, it is well to space boiler and superheater tubes so that possibility of bridging over the gas passages is minimized. An adequate soot-blowing system, for both furnace walls and convection surfaces, must be provided and used at frequent intervals. The dislodged dust should then be removed immediately from the collecting hoppers. Dust collectors should also be installed to reduce dust loading of the flue gas to a reasonable low level before it enters the induced-draft fans.

Air for combustion should preferably be preheated to temperatures as high as 400 F to accelerate drying and burning. Under this condition flames are short and bright, and it is almost impossible to cause smoke. Stratification of the furnace gas stream is overcome through the use of properly placed and directed overfire air streams.

During 1947 and 1948 the Otter Tail Power Company contracted for three spreader-stoker-fired steam generating units all designed for operation with North Dakota lignite. The units were installed at Ortonville, Minn.; Devils Lake, N. Dak.; and Jamestown, N. Dak. That at Ortonville, shown in Fig. 8, has a maximum continuous capacity of 160,000 lb per hr at 875 psi and 900 F. The guaranteed efficiency at this capacity is 77.9 per cent with an exit gas temperature of 355 F. The grate release rate is approximately 600,000 Btu per sq ft per hr with a corresponding furnace rate of 21,700 Btu per cu ft. Temperature of air for combustion is 375 F. This unit has operated satisfactorily over a wide capacity range and is performing approximately as guaranteed.

The unit at Jamestown is similar to Ortonville except the continuous steaming capacity is 100,000 lb per hr at 650 psi and 825 F.

The unit at Devils Lake is designed for 100,000 lb per hr at 420 psi and 750 F. Although the boiler and furnace are similar to Ortonville and Jamestown, the stoker is different in that it discharges to the rear. Reversing the stoker travel makes it necessary for the operator to carefully regulate the "throw" of fuel to the grate. Excessive length of throw will cause increase in ash-pit carbon loss and a corresponding decrease in efficiency. Other than this the operation is the same as for front-discharge types.

Recently there has been tested a new type of spreader installation built for The Chesapeake Corp. at West Point, Va.; see Fig. 9. The primary fuel is wet bark and wood refuse from paper mill operation. Auxiliary fuels are coal and oil. The principal difference between this unit and the conventional one is that the spreader distributor is located 17 ft above the grate. Practically all of the combustion air is supplied overfire, through tangential nozzles, located between the distributor and the grate. By using this arrangement it is possible to flash dry the incoming fuel, liberate and burn a large portion of the volatile matter and fixed carbon in suspension, and set up a high degree of turbulence immediately above the fuel bed. Performance has exceeded guarantees by a wide margin. It is of interest to know that the grate release rates for both coal and wood at 145,000 lb per hr are above 900,000 Btu per sq ft per hour. Mr. R. Ellwanger, chief engineer of The Chesapeake Corp., presented a paper discussing operation of this unit, before the Technical Association of the Pulp and Papermill Industry (TAPPI) on September 26 at Richmond, Va.[1]

The new principles incorporated in this unit are well suited to the low-rank fuels of the Northern Great Plains Province.

Pulverized Fuel

The burning of subbituminous coal and lignite in pulverized form is not new. There are, however, two factors which require special attention: the heating value is low, so that the boiler requires considerably more fuel than when burning high-rank coal, and therefore the pulverizer must be larger; and the pulverizer must be suited to grinding wet coal. Once pulverized, these low-rank fuels are at least equal to the high-rank ones. Ignition is stable and operating adjustments are not critical; combustion is completed rapidly; and the flames are relatively short.

In 1924 the Texas Power and Light Co. and the San Antonio Public Service Co. became interested in the possibility of using pulverized Texas lignite as a boiler fuel. Arrangements were made to try this fuel in a steam generating unit at the Island Station of the St. Paul Gas Light Co. As yet so-called "mill drying" had not been developed, and external dryers were therefore used to reduce the moisture in the fuel before it was supplied to the pulverizer. After pulverization the fuel was stored in overhead bunkers and withdrawn as required. The unit on which these tests were run consisted of a 10,440 sq ft straight-tube boiler with combination convection and radiant superheating surface. The radiant superheater was installed in the rear furnace wall. The vertically fired furnace was of the air-cooled refractory type equipped with a bottom water screen. The furnace volume approximated 8000 cu ft. Roller type mills were used to pulverize the lignite. Test efficiency ranged from 78 to 76 per cent with furnace heat releases of 12,850 and 22,400 Btu per cu ft per hr, respectively.

As a result of these tests several vertically fired units were installed in the Comal Station of the San Antonio Public Service Co. Furnaces of the first units had bottom water screens, fully water-cooled rear walls, and approximately 60 per cent water cooling on the side walls. In a later unit of similar design the side walls were fully cooled. A number of operating difficulties were encountered but easily overcome During one test[2] the unit

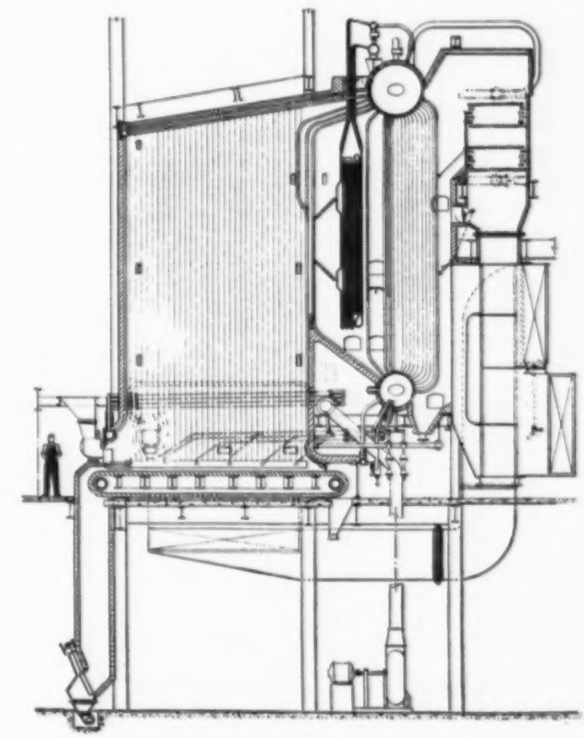


Fig. 8—A spreader-stoker-fired steam-generating unit installed at Ortonville, Minn.

was operated at a capacity of 245,000 lb per hr for a period of $7^1/_2$ hr with an efficiency of 81.8 per cent. The furnace liberation rate was 18,400 Btu per cu ft per hr. The gas temperature at air heater outlet was 423 F. The fuel was Texas lignite, moisture 29.05 per cent and ash 10.60 per cent. Other equally successful units were operated for a number of years at the Trinidad Station of the Texas Power and Light Co.

In 1945 two steam-generating units were purchased by the East Kootenay Power Co. for their plant at Sentinel, Alberta. These units are of the two-drum steam-generator type with fully water-cooled furnaces. The pulverizers are arranged for mill drying and deliver the dried pulverized fuel directly to vertical type burners located in the furnace roof. The unit has a design capacity of 90,000 lb steam per hr when burning Crows Nest Pass low-volatile bituminous coal and is equipped with an air heater. During 1947 two tests were run with Souris lignite bug dust having the following analysis: moisture 31.87 per cent, ash 6.26 per cent and heating value 7560 Btu per lb (as fired). The results showed efficiencies of

[1] For an abstract of this paper see the October 1951 issue of COMBUSTION.

[2] "Operating Experience Proves Pulverized Lignite a Satisfactory Fuel," by V. H. Braunig, Superintendent Electric Dept., San Antonio Public Service Company, *Power*, July 2, 1929.

79.7 and 80 per cent; furnace heat releases of 16,700 and 20,400 Btu per cu ft per hr. Combustible in the fly ash ranged from 2.6 to 4.8 per cent.

The fibrous character of North Dakota lignite has caused some engineers to feel that it was not well suited to pulverized fuel firing. This is not the case, however, because with suitable milling equipment and adequate air temperature for mill drying, pulverization may be easily carried out to the degree necessary for good firing

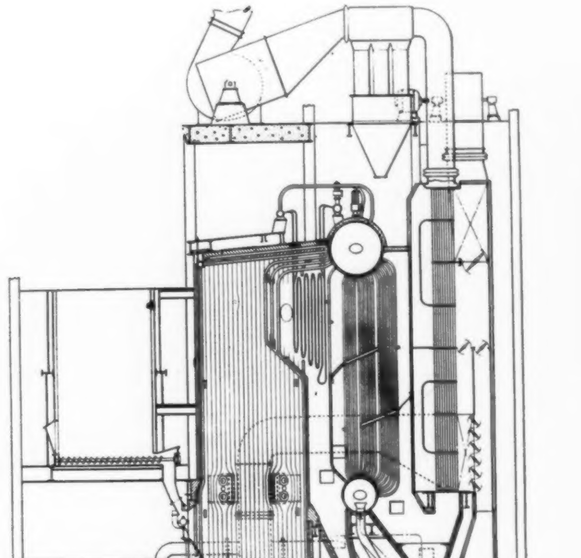


Fig. 9—A steam-generating unit with "high-set" spreader stoker installed for The Chesapeake Corp. at West Point, Va.

conditions. During January 1950 a demonstration trial was run on a horizontally fired steam-generating unit at the Nekoosa-Edwards Paper Co. using North Dakota lignite. There were no difficulties encountered in pulverizing or burning this fuel.

Also, the Central Power Electric Cooperative, Inc., at Voltaire, N. Dak., is now about ready to start up a new pulverized lignite-fired steam-generating installation. The two units are designed for a guaranteed continuous capacity of 230,000 lb steam per hr at 865 psi, 905 F, and an overall efficiency of 80 per cent with a corresponding liberation rate of 18,000 Btu per cu ft per hour. The furnace is fully water cooled, and horizontal turbulent-type burners are used. An air preheater suppplies air at 675 F, part of which is used for mill drying during pulverization. The North Dakota lignite will originate from near the plant site, and its analysis will be approximately: moisture 39.0 per cent, ash 6.6 per cent, heating value 6600 Btu per lb (as-fired).

Conclusion

For units up to approximately 200,000 lb per hr either traveling-grate or spreader stokers may be selected. In the range from 75,000 lb per hr and over, pulverized-coal firing should receive careful consideration. One very great advantage of a pulverized-coal installation is the ease and rapidity with which it can be switched over to other fuels. This is particularly true now that North and South Dakota are in the ranks of petroleum-producing states. Natural gas may also become available in the not too distant future. Therefore a multi-purpose design is one which stands ready to take advantage of rapid changes in fuel supply and price.

Water Conference Held in Pittsburgh

WITH an attendance of more than 400 engineers and chemists the Twelfth Annual Water Conference, sponsored by the Engineers' Society of Western Pennsylvania and held at the Hotel William Penn, Pittsburgh, Pa., October 22–24, stands out as one of the most successful in the entire series.[1] Practically every state east of the Mississippi River and several provinces of Canada were represented by those who heard and presented the ten formal papers and the panel discussion on chemical cleaning of boilers. The latter proved to be the high light of the conference, bringing forth especially vigorous discussion on the relative merits of phosphoric and hydrochloric acid in boiler cleaning, as well as focussing attention on phases of chemical cleaning that have previously received relatively little consideration by the technical press.

Progress Report on Hot Lime Zeolite

William S. Butler of the Ludington Division of The Dow Chemical Co. presented "An Inspection Report After 18 Months With Hot Lime Zeolite," supplementing a paper presented at the 1950 ASME Annual Meeting.[2] The Ludington plant originally operated on the hot lime-soda, secondary-phosphate process but in 1949 was changed to the hot lime-soda, secondary-zeolite process, operating without prefiltration.

Operating experience with the new treatment dictated some changes, including the revising of the primary sedimentation tank and the rebuilding of the zeolite softeners to permit a bed depth of 30 in. of Nalcite HCR. At the present time an operating rate of 150,000 lb per hr is possible while maintaining a flow rate of 3 gpm per sq ft through the primary softener and the three zeolite units. It was reported that the steam generating units, using hot lime-zeolite treated makeup, have not been cleaned in over two years and that no adherent scale was found when an inspection was made of the boiler tubes. This is in contrast to the dirty condition and sludge deposits which necessitated boiler cleaning every six months when the phosphate softeners were used.

To make the operation of the water-treating equipment more nearly automatic, a pH recorder and controller have been installed. A lime feed having five per cent of the concentration of the regular lime batch is connected through the controller which maintains a pH of 10.1 plus or minus 0.1 pH with only a slight change in hydrate alkalinity. In order to complete the control of primary softener operation, desludging is carried out automatically at intervals according to the quantity of water being fed to the softener.

With the deeper resin beds a better quality of water has been obtained. Hardness values of less than 0.5 ppm $CaCO_3$ are more readily realized. The new beds have an exchange capacity of nearly 27,000 grains per cubic foot as $CaCO_3$, an increase of 2000 over the shallower beds. This permits handling a greater quantity of water between regenerations.

A comparison of chemical costs of the two methods of treatment shows that for complete hardness removal from 175 ppm hardness water the cost for the hot lime-zeolite system has been close to 2.6 cents per thousand gallons treated. By way of contrast, the hot lime-soda phosphate system operated at a cost of 3.75 cents per thousand gallons when treating the same water supply.

Discussion

Several comments were made about the rapidity with which the hot lime-zeolite method has been accepted for use in industrial and utility power plants. One manufacturer reported having obtained contracts for equipment covering a combined treatment capacity of one million gallons per hour. Among the advantages cited for the process are the excellent quality of effluent produced, relative lack of deterioration of ion-exchange resins, reduced operating cost, and obtaining water of nearly zero hardness by using zeolite as a finishing and scavenging treatment.

Evaporator Purity Testing

"Factors in Evaporator Vapor Purity Testing" was the subject of a paper by **J. T. O'Rourke,** formerly of the Alco Products Division of the American Locomotive Co. One of the greatest difficulties encountered in this type of testing is to obtain a representative sample of the vapor produced. An attempt should be made to obtain both moisture and vapor in their respective volumes in order that a representative count of all impurities carried over by the evaporator may be made. Two deterrents to this objective are rapid changes in shell pressure and foaming within the evaporator, although the latter may be observed with the aid of a sight glass.

Mr. O'Rourke gave details of commercial acceptance tests of two evaporators, employing both gravimetric analyses and conductivity measurements. In his concluding remarks he offered these recommendations:

1. Location of sampling nozzle should be given consideration when station piping is laid out.
2. Sampling and test-coil piping should be of stainless steel or Monel metal.
3. Heat head between shell and coil side of evaporator should be low (20 to 25 psi) to prevent violent ebullition of shell liquor.
4. Method of testing and limits of its accuracy should be established in advance.
5. Float control for shell liquid level should be of a type that has shortest possible lag between changing of level and opening of feed valve.

Discussion

Several engineers who discussed this paper agreed with the scope of the testing problems outlined in the paper. It was pointed out that good quality evaporator vapor is exceptionally aggressive to glassware, and that minute amounts of dust and dirt may affect the results of gravimetric analysis. Collecting samples in a tightly closed atmosphere, using vessels of platinum or stainless steel was recommended. Regarding location of the sampling nozzle, one engineer advocated placing it in the outlet of the evaporator, with the vapor piping arranged to avoid reentrainment of moisture. Another commented on the difficulty of holding power plant conditions constant during the time of evaporator testing and wondered if a sample had ever been taken based on an entire day's operation.

Compression Distillation

In a paper on this subject **O. M. Elliott,** consulting engineer, traced the historical development which dates back as early as 1856 and is based upon the thermodynamic principle of recirculation of latent heat of evaporation in compression stills. In this way the latent heat is largely recirculated within the condenser-evaporator without the use of multiple stages. With a single-effect evaporator, on the other hand, only part of the sensible heat of the condensate and continuous blowdown can be salvaged by heat exchangers. A diesel-driven vapor-compression distillation unit can produce ten to fifteen times as much water per pound of fuel as a single-effect evaporator and is much simpler to operate than a multiple-effect evaporator.

During World War II 6500 portable engine-driven compression stills were built for the U. S. Marine Corps and the Army in sizes ranging from 750 to 6000 gallons of distilled water per day. Their combined capacity was sufficient to meet the fresh water needs of more than a million men. This practical application of compression distillation was dependent upon the development of suitable steam compressors capable of meeting high standards of distilled water. For the portable military units the choice was a rotary-type positive-displacement compressor having lobes that roll together without contact, aided by external timing gears.

Regarding quality of distillate, Mr. Elliott reported that it is uniformly good because the steam generating rate in a compression still cannot be varied as easily as in a single-effect evaporator. When operating on sea water, it is normal to obtain distillate having less than 0.1 grain per gallon sodium chloride and also free from harmful bacteria and pyrogens.

In marine service compression distillation makes smaller fresh water storage practical. The author cited a hypothetical case of an oil tanker on the Texas-

[1] Copies of the Proceedings, including complete papers and discussions, may be obtained for \$7.50 by writing the Society office at the same Hotel.

[2] See COMBUSTION, December 1950. Vol. 22, No.6, pp.55–56, for abstract.

Philadelphia run in which compression distillation equipment could make available cargo space valued at $342 per trip and provide annual savings of $3200 per year, assuming an installation cost of about $50,000 for distillation units and amortization over a ten-year period.

Discussion

It was brought out in the discussion that compression distillation represents a special application of the heat pump and that it may have future significance for the power industry because of the high-quality water that can be produced. At present the stills are operated at atmospheric pressure, although there has been some experience in Europe at higher pressures. Vacuum distillation is another possibility.

Treatment for Packaged Boilers

In a paper entitled "Feedwater Treatment for Packaged Steam Generators," **J. F. Wilkes** and **E. M. Welch** of Dearborn Chemical Co. described several types of these generators, discussed design features contributing to water-treatment problems, and listed water-treatment requirements. They also described some of the problems of field operation and gave attention to chemical proportioners and feedwater conditioning units developed for use with packaged steam generators.

The general principles governing the treatment for packaged steam generators are identical with those applicable to conventional boilers. The major differences in procedures required are traceable to the increased heat transfer and steaming rate of the packaged units, limited steam storage capacity, and the shorter time available for completion of softening reactions or neutralization of corrosive tendencies. Some changes in water-treatment procedure are necessitated because of the automatic operation of packaged units.

Requirements for corrective water treatment are as follows:

1. Scale-forming minerals must be totally removed from feedwater or converted into soluble salts or precipitated in the form of a free-flowing, non-adhering sludge readily removed from the boiler by blowdown.
2. Dissolved, corrosive gases must be neutralized or removed.
3. Protective alkalinity must be provided to prevent aggressive attack on boiler metal.
4. Foam-control chemicals must be provided to help maintain boiler efficiency and steam quality.
5. Protection must be provided against embrittlement, stress corrosion, hideout and caustic corrosion.
6. Feedwater must be conditioned to prevent incrustation of feed lines and auxiliaries.
7. Condensate return lines must be protected against corrosion.
8. The system of feedwater treatment must be unified, efficient and capable of operating continuously with a minimum of supervision and maintenance.

In concluding the authors emphasized that treatment materials and methods must be tailored to fit the water characteristics of any given location. Experience has indicated the advisability of presoftening feedwater whenever possible, particularly when the units are to be operated at locations where adequate supervision and control of internal treatment procedures is difficult. "Packaged treatment plans" have been developed which include provisions for softener, chemical tank, proportioning pumps and controls, adequate stocks of suitable after-treatment, and equipment for periodic test control. To insure complete protection, engineering supervision and laboratory services are furnished.

Discussion

N. O. Kirkby of Vapor Heating Corp. noted that with application of the railway-type forced-circulation generator to stationary practice, more water-treatment problems may be expected. Because of the small amount of chemicals required for treatment, combined with specialized service for each installation, water conditioning presents a challenge to the water treatment industry to provide services to small users at a reasonable cost.

B. J. Cross of Combustion Engineering-Superheater, Inc., pointed out that the same high degree of technical skill cannot be expected in the operation of packaged steam generators as has been found necessary for much larger units. Therefore, the problem is to simplify the application and supervision and still retain the protective conditions against scale and corrosion. The authors' proposal to supply a package treatment is a logical approach, though quite a number of types of chemical packages would be required because of the great geographical variations in water quality.

Steam Sampling

"Steam Testing for Operating Control Can Be Simple" was the subject of a paper by **Frank U. Neat** of the Consolidated Gas Electric Light & Power Co. of Baltimore in which the author reviewed some of the confusion and inconsistencies in the literature on steam sampling. He expressed this philosophy for keeping sampling simple:

"Take samples which can be compared to one another; control the temperature of the samples; make sure your instruments are right. Then, for operating control, just see to it that all samples are of equal quality."

In designing steam sampling equipment, the following knowledge should be used. If there are ionizable substances in the sample, its conductivity will be greater than pure water. In all probability there will be solids in the water which may be ionized slightly or not at all. Carbon dioxide and ammonia may be present and will contribute to the conductivity of the sample. There is also the possibility of hydrogen sulfide and sulfur dioxide being present.

The actual sampling systems reported upon are designed so that one sample may be checked against another. The stea m is sampled at at least two points and these samples may be checked against the total condensate produced by the main condensers. Temperatures are controllable and no correction for them is necessary. At the first sign of departure from normal quality of any one or more samples, a check system is instituted to determine source of trouble. Among the difficulties diagnosed by these sampling techniques were (1) several failures of attemperators, (2) welding slag in the sampling system, (3) dirty condenser coolers, (4) condensation in attemperators, (5) condenser leakage, (6) loss of two adjacent bolts in steam baffling, and (7) lodging of a single piece of coal in a cyclone steam separator.

Discussion

Prof. **D. S. McKinney** of Carnegie Institute of Technology suggested that the accuracy of various methods of steam sampling might be checked by using an air or gas stream containing a measured weight of dust to determine whether or not the proper proportions are being collected.

E. A. Pirsh of The Babock & Wilcox Co. observed that conductivity readings do not always give an absolute value of purity and sometimes may be misleading. On the other hand, there have been cases in which trouble was indicated by conductivity recorders but went unrecognized by operators until failure took place.

P. B. Place of Combustion Engineering-Superheater, Inc., commented that interpretation of results is one of the most important factors in steam sampling and that absence of operating difficulties is an accepted test of steam purity. He added that a distinction must be made between two types of tests: (1) those for determining the absolute and average purity of a large mass of steam by sampling and testing a very small portion of that mass, and (2) those used as controls of operating conditions to determine variations that may cause trouble. In the latter case, continuity and stability of the meter record are of prime importance. Since carryover is not necessarily uniformly distributed, it may be of greater value in the second instance to sample at a point where carryover is likely to concentrate and where it will be more quickly detected.

Chemical Cleaning of Boilers

Nine engineers and chemists constituted the panel on chemical cleaning, ably presided over by **S. F. Whirl** of Duquesne Light Co. Opening the discussion was **E. A. Pirsh** of The Babcock & Wilcox Co., who indicated that the primary objective of alkaline boil-out of new boilers is to remove the water- and alkali-soluble and saponifiable materials from the internal surfaces of the boiler. Prior to boiling out the unit should be filled to the normal operating level with water of a quality equal to or approaching that of the feedwater to be used in regular service. Recommended pressure for this operation was given as 50 per cent of normal operating pressure. With recommended chemical concentrations at this pressure, a period of 48 hours is usually sufficient to clean a unit.

Answering the question, "Should new boilers be acid cleaned?" **I. B. Dick** of the Consolidated Edison Co. of New York reported that acid cleaning eliminated

"black water" formed in the initial operation of boilers that had gone into service without acid cleaning for mill scale removal. Internal surfaces of the boiler are left metal clean and the objectionable conditions attendant upon black water are avoided with acid cleaning. This is based upon experience with nine high-pressure boilers going into service prior to 1943 without acid cleaning and eight high-pressure boilers that have been acid-cleaned since that date. Mr. Dick advocated that alkaline boil-out should precede and follow acid cleaning. In the latter case the alkaline treatment serves the triple purpose of neutralizing residual acid, removing residual hydrogen, and leaving a slightly protective film on the metal.

"Advantages of Chemical Cleaning of Serviced Boilers" was the subject of remarks given by **A. M. Guy** of Commonwealth Services Inc. He observed that starting up a steam generator that has been properly chemically cleaned and protected with the desired oxide film is the same as again putting on the line, at least with respect to the water side of the unit, a brand new boiler. Among other advantages he noted the control of the protective iron oxide film, the fact that chemical cleaning requires less time and does a better job than mechanical cleaning, and the increased ease of inspection and location of questionable areas within the boiler tubes, headers, and drums. Minor disadvantages are the possible superficial rusting of freshly pickled surfaces before an adequate protective film can be provided and the attack on handhole and manhole head gaskets and seats, though there are means for controlling both.

W. R. Elliott of Solvent Service, Inc., outlined procedures for chemical cleaning of boilers. The dilute-fill method is most commonly used on water-tube boilers. An external water and steam supply is connected to a heating and mixing device, and the dilute hot acid is put into the boiler through a blowdown line, the boiler being filled to a predetermined level. Generally a 5 to 7 per cent inhibited solution is pumped at 150 to 160 F. Upon filling the boiler there is a soaking period, followed by flushing. To prevent iron oxide from forming during flushing, a procedure has been adopted for introducing nitrogen. The concentrated fill method is used with fire-tube boilers, utilizing hot water from the boiler. A specified amount is drained from the unit, and the boiler is refilled with an equivalent amount of concentrated acid. As a result of the subsequent chemical reaction with the scale in the boiler, violent agitation is set up which accomplishes a thorough mixing and cleaning.

E. B. Morris reported experience on the American Gas & Electric System in which over the past nine years 22 high-pressure boilers (ranging from 1300 to 2450 psig and rated from 300,000 to 1,000,000 lb per hr) have been cleaned a total of 43 times. Corrosion is an ever present menace during acid cleaning, but by appropriate control of the factors involved such attack can be reduced to insignificant proportions. Corrosion rates increase with acid concentration and with increase in temperature, the latter being probably the greatest single contributor to corrosion. The time that acid solvents are in contact with deposits is important from the standpoint of efficient removal. An estimate was made that 25 acid cleanings could take place before serious loss of metal becomes evident. With proper cooperation between equipment owners and cleaning service organizations, corrosion can be minimized.

P. H. Cardwell of Dowell Incorporated stated that it is important to control after-deposits resulting from chemical cleaning (using the customary procedure with inhibited hydrochloric acid and soda ash) in order to obtain the maximum amount of protection with minimum corrosion of boiler metal. The amount of after-deposit left upon the metal depends primarily upon the amount of rusting which occurs during the draining of the acid and the water rinses. The amount of rusting at this point in turn depends upon the length of time the wet metal surface is in contact with air, the temperature at which the boiler is drained, the composition of the acid and the composition of the boiler metal. At drainage temperatures within the range of 130 to 160 F magnetic black iron oxide forms a major proportion of the film, while within the range of 100 to 130 F gamma iron oxide (reddish film) is more in evidence. To reduce and control rusting during drainage, water or nitrogen is used to displace acid from the boiler.

H. J. Thielke of Niagara Mohawk Power Corporation centered his remarks on safety procedures during chemical cleaning. He reported on a survey by the Power Station Sub-committee of the Prime Movers Committee of the Edison Electric Institute, in which there were only two accidents in 842 cleaning jobs involving a variety of power plant equipment in 26 plants. The same survey reports that 365 boilers were cleaned and only one accident reported. Safety practices should include proper supervision, protection against spilling of corrosive materials, knowledge of toxic properties of inhibitors, physical isolation of unit to be cleaned, venting of gases (with special provisions for combustible gases), and provision to neutralize acid, to purge the unit and to carry out satisfactory inspection.

J. A. Tash of Duquesne Light Company listed as inherent advantages of phosphoric acid: (*a*) its basic stability; (*b*) a much lower level of attack on boiler metal; and (*c*) its ability to produce a corrosion-resistant film on treated metal surfaces.

He offered the following conclusions:

1. Phosphoric acid is a good solvent for acid cleaning of boilers.
2. Inhibited phosphoric acid solution can be boiled at atmospheric pressure with negligible attack on boiler metal, thus permitting the solution to be heated and circulated by normal low-level firing of the boiler.
3. Phosphoric acid solutions are stable at atmospheric boiling and yield no corrosive vapors above the solution or noxious fumes in the plant.
4. Boiler surfaces cleaned with phosphoric acid are resistant to rusting.
5. Following the cleaning of a new unit with inhibited phosphoric acid, the boiler water during subsequent operation was clear and free of black iron oxide suspensions.

"Removal of Copper from Boilers" was the topic of **R. F. Andres** of Dayton Power & Light Co. who pointed out that metallic copper, although relatively insoluble in hydrochloric acid, tends to go into solution during acid cleaning because of the presence of ferric ion in the acid solution. The copper can then replate and may or may not be adherent. Deposits may then collect in areas where circulation is less rapid, further impeding circulation and sometimes causing overheating and ultimate tube failure. Although mechanical cleaning following acid treatment is one method of removing copper, this procedure is both time consuming and expensive. Mr. Andres reported on a chemical cleaning method for removing copper in which ammonia base oxidizing solvents have been used, their effectiveness being based on the reaction of an oxidizing agent on metallic copper to form cupric oxide. This is then dissolved in the ammoniacal salt solution to form the soluble cupric-ammonium complex ion. Over the past two and a half years thirteen boilers have been chemically treated for copper removal which has been estimated as 90 to 100 per cent complete. This compares favorably with the efficiency for iron oxide removal by acid treatment, and likewise the cost for copper removal is comparable with that for acid cleaning treatment.

G. C. Walker of Sumco Engineering Company discussed inhibitor effectiveness at elevated temperatures and reported that an inhibitor had been developed that permits cleaning with normal strength hydrochloric acid at temperatures as high as 185 F with metal attack resulting only to a negligible degree. Results of more than 100 cleaning operations over a six-month period have shown removal effectiveness of cleaning between 175 and 185 F, both in reducing the time element and in the final cleanliness of metal surfaces.

Anion Exchangers for Silica Removal

"Silica Removal Characteristics of Highly Basic Anion Exchangers" was the subject of a paper by **M. E. Gilwood, C. Calmon** and **A. H. Greer** of The Permutit Company. About five years ago it was demonstrated that a resin containing quaternary amine groups in its structure was capable of absorbing silica from water when the resin was regenerated with sodium hydroxide. In the past three years two new types of strongly basic anion exchange resins have become available for removing silica. These employ polystyrene as their foundation matrix, to which the active quaternary amine groups are attached. Type I contains only alkyl quaternary groups, while Type II has some alkanol groups in the quaternary structure.

Main applications of these resins have been in the two-step and the mixed-bed demineralizing processes. To date operating costs in the two-step installations appear more economical than for mixed beds. Type II resins are now almost ex-

clusively used for silica removal because they give much higher exchange capacities to a silica endpoint than the Type I resins. However, a number of laboratory and field tests showed some deterioration in usage, as compared to Type I resins. A careful economic analysis must be made to determine which type is better for long term treatment, especially when designing demineralizing plants to treat waters containing high proportions of silica to total acids. In the design stage some allowance should be made for the decrease in capacity after the resins have been in operation a few hundred runs.

Laboratory tests were run with resins of both types employing mixed-bed and two-step demineralizing to determine if any noticeable difference in silica residuals could be observed. Although the mixed-bed demineralizer produced a water of 5 to 15 million ohms resistance, its silica content did not appear to be lower than that obtained in a two-step demineralizer where the electrical resistance of the water was about 150,000 to 200,000 ohms. The authors mentioned the necessity of obtaining reliable power plant operating data to determine what are the respective advantages of the two types of demineralizers.

Discussion

A marked difference of opinion existed as to the amount of deterioration taking place in long term usage of resins, and a representative of one resin manufacturer insisted that there was no decrease in resin basicity and capacity. Another reported that he found it difficult to correlate laboratory data given in the paper with field data obtained by his organization. One apparently constructive outcome of the discussion was general agreement that designs of demineralizing equipment should be more conservative to allow for possible resin deterioration.

Concentrating Films

H. M. Rivers of Hall Laboratories, Inc., presented a paper entitled "Concentrating Films: Their Role in Boiler Scale and Corrosion Problems" in which he traced some of the history of scale-formation treatment and outlined the concept of concentrating films on steaming surfaces. When steam is being generated, evaporation continues at the metal-water interface until the boiling temperature of the concentrating film approximates that of the metal surface. If the rinsing of the boiler water is too slow with respect to the rate of bubble formation, and if nonboiling equilibrium does not occur before saturation is reached for some constituent in the boiler water, precipitation will take place as a deposit on the metal of that constituent. All of the substances which might precipitate in this way may be thrown out of solution before the concentrating film comes to nonboiling equilibrium. If some caustic alkalinity remains in the concentrating film after precipitation of most of the dissolved salts, caustic may concentrate to a high degree before nonboiling equilibrium is reached.

The character of the final solution on the steaming surface depends upon the relative amounts and types of impurities in boiler water, the rate of heat transfer, and the vigor with which boiler water flushes the surface. Deposition can be minimized (1) by reducing the heat input to obtain lower concentrations in the films; (2) by increasing velocity and turbulence of the boiler water to dissipate concentrating films more rapidly; (3) by modifying boiler water to exclude constituents that tend to crystallize or produce adherent residues under concentrating film conditions; (4) by adding agents to dispense suspended solids and allow them to be rinsed more freely; and (5) by reducing the total amount of dissolved and suspended matter in boiler water.

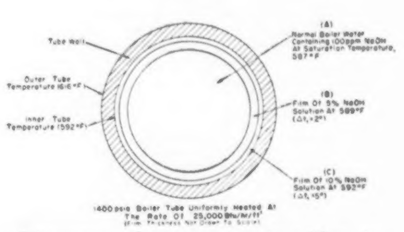


Diagram of concentrating film in boiler tube

In concluding, Mr. Rivers defined the water consultant's task as one of providing boiler water so that (1) salts which accumulate in concentrating films either fail to crystallize out or precipitate in forms that do not continuously accumulate; (2) treatment chemicals and other boiler water constituents do not give trouble by decomposition or volatilization under film conditions; and (3) corrosive concentrations of free causticity are avoided. In turn, the boiler manufacturer is expected to design for heat input rates that limit the tendency toward excessive film concentration and to provide sufficient circulation and turbulence to assure adequate rinsing of all steaming surfaces.

Discussion

It was pointed out that the solubility of the material that deposits determines whether or not deposits progressively increase in thickness or disappear through rinsing action. One engineer questioned whether a stable quiescent layer was actually laid down as a concentrating film as proposed in the paper. Another commented that little is known about the effective thickness of films at the water-metal interface in boilers. Many of the problems posed by the paper are of a fundamental nature and may be outside the scope of a typical industrial laboratory.

Iron Oxide Deposits

R. C. Ulmer and **J. H. Whitney** of the Power Chemicals Division of E. F. Drew & Co. presented a paper entitled "Cause and Control of Iron Oxide Deposits in High-Pressure Boilers" which dealt with means for eliminating deposits which may be the cause of overheating and tube failure.

Three possible ways of eliminating iron oxide deposit formation are through (1) finding the source of the iron and preventing it from entering the boiler if the source is external; (2) modifying the physical characteristics of the iron oxide so that it will not adhere; and (3) altering the iron oxide chemically to prevent adherence to the boiler tube metal. The authors conducted experiments the emphasis of which was on converting the iron oxide to a harmless sludge.

Several runs were made on a laboratory-type boiler to determine whether or not magnetic iron oxide scale could be produced. Iron in the feed was adjusted to give 50 ppm of ferrous iron, and caustic and phosphate were added. Magnetic iron oxide scale was produced. The iron which appeared in the blowdown could be easily drawn by a magnet. That adhering to the tube had a black to purple, satiny sheen. The deposits on the tube could be removed only with great difficulty and were also very strongly attracted by a magnet.

Experiments were made using organic additives to attempt a modification of the physical nature of the magnetic iron oxide scale. Three materials were used, but the results were not very promising. The magnetic iron oxide was not noticeably less adherent, and the scale, when removed, was attracted by a magnet as strongly as ever.

An attempt was next made to alter the magnetic iron oxide chemically, using oxygen supplying materials. Following preliminary tests, nitrite, hypochlorite and peroxide type products were tried in the laboratory-type boiler. Instead of forming magnetic iron oxide, these materials cause the formation of a fluffy, easily removed deposit in the form of gamma Fe_2O_3, the red iron oxide. Further experiments were made on tubes which had previously been coated with magnetic iron oxide. When a second run was made with these tubes and a nitrite-type inhibitor added, the scale deposits were converted to non-magnetic iron oxide.

The authors reported that the oxidizing treatment has been used successfully for ten years in marine boilers operating at pressures up to 1500 psig.

Discussion

B. J. Cross of Combustion Engineering-Superheater, Inc., noted that the proposal of having oxidizing conditions in boiler water represented a departure from conventional practice of maintaining reducing conditions and was not likely to be accepted without a very convincing argument. Since the experimental boiler was operated with a 10 per cent blowdown, a still further credit would accrue to the proposed method of treatment if the oxide sludge could be removed from the blowdown, thus preventing deposits on the heating surfaces. Mr. Cross also felt that greater emphasis should be placed upon the prevention of corrosion in the pre-boiler water system.

Frank Clarke of the U. S. Naval Experimental Station at Annapolis raised the question of cause and effect: whether overheating of tubes caused deposits of black magnetic iron oxide or whether the latter were the cause of overheating. He praised the authors for proposing a novel treatment backed up by experimental evidence.

Fourteenth Annual Fuels Conference

THE Fuels Division of the ASME and the Coal Division of the AIME held their Fourteenth Joint Conference at the Roanoke Hotel, Roanoke, Virginia, October 11 and 12, with technical sessions divided between subjects having to do with mining operations and those pertaining to fuel selection and application. Engineering service provided by the coal industry was the theme of the first panel discussion and the second dealt with fuel and equipment consulting service for small steam generating plants. This report will omit reference to papers dealing with mining operations. Registration totaled 241.

Fuel Engineering Service

At a panel discussion dealing with "Engineering Service in the Coal Industry," **U. B. Yeager** of the Island Creek Coal Sales Co. discussed the service functions of combustion engineers employed by coal producers. These he enumerated as:

1. Study of the prospect's or customer's problem, including a survey of the equipment and operating conditions with a view to recommending the most suitable fuel.
2. Equate the cost with that of competing fuels.
3. Work closely with the customers and plant operators and offer suggestions whenever savings are possible. In turn, the service engineer may gain valuable information. He should keep well informed, broadly, in order to be able to offer assistance.
4. The service engineer can sometimes assist the operating group in obtaining needed equipment from management.
5. Some industrial establishments are inclined to overlook the importance of their boiler plants as a component in the output cost of their products.
6. The coal service engineer can often be of help to small plants where charges for consulting service might be relatively too costly.
7. The retailer often needs assistance.

A similar line of advice was given by **Max A. Tuttle** of the Enos Coal Mining Co. who added that the coal service engineer should have the ability to read and properly analyze a fuel bed and flame line without the use of instruments; also that he should possess the knack of getting along with people, appreciate the limitations of existing plant equipment and personnel, and realize acceptable efficiency and performance.

Another speaker was **G. P. Cooper** of Empire-Hanna Corporation who discussed Canadian practice. He was of the opinion that sometimes the selection of proper fuel is handicapped either by lack of knowledge of the requirements or through lack of knowlege of the part of the salesman as to what his company's coals will do. He listed a set of questions that should be answered in a survey of coal requirements and showed slides of survey forms.

Inasmuch as few small plants have the necessary knowledge or equipment to make tests, these often must be made by the service engineer. In central Canada where a variety of coals are available the problem is quite different from that in restricted regions where there is little variation in coal characteristics. A mixture of 60 per cent lignite and 40 per cent bituminous coal is frequently employed in western Canada, whereas in the Province of Quebec low ash-fusion coals from Nova Scotia are widely burned. In Ontario there is considerable competition from electric boilers.

The fourth speaker on the Panel was **E. J. Kerr** of the Baltimore & Ohio Railroad who discussed the fuel servicing problem from the railroad angle. It is important, he pointed out, that such service be made available to selling companies so that a coal can be traced to its source and periodic checkups maintained. By such means the small plant operator or owner can often be dissuaded from turning to competitive fuels. Also, due to a large amount of accumulated data in the hands of railroads it is possible to give information to sales agents along the line as to potential outlets. Such service, if properly handled, should not duplicate that offered by the mines and should also be directed as assisting those producers who do not have their own engineers. Architects and plant designers are often contacted with reference to availability and cost of coal as factors in selection of site.

Discussions of these papers from the floor stressed the need for more fuel service engineers; a need for the engineering colleges to educate more men to go into this line; and the importance of offering such salaries as will attract and hold competent men.

Air Pollution from Gob Piles

"Gob piles," as explained by **Henry F. Hebley** of Pittsburgh Consolidation Coal Company, are made up of the reject material from coal preparation plants which, in addition to rock, varies in combustible material from practically nothing to almost pure coal. The carbonaceous matter is frequently accompanied by varying percentages of pyrite and marcasite. This discarded material is heterogeneous, it ignites and may burn readily for months, or even years, giving off fumes which are disagreeable to adjacent communities, particularly miners' dwellings.

With the more recent agitation for betterment of atmospheric conditions in general, pollution by burning gob piles has also come in for attention through research. This particular problem is being attacked through a fundamental study of the various combustibles associated with mine refuse in an effort to determine the causes of such spontaneous combustion and the combustible that is conducive to such combustion. Plans are also being formulated to explore the possibilities of the removal of a large percentage of the pyritic content and recovery of the sulfur as a by-product.

Mr. Hebley then reviewed the control legislation being studied, or adopted, for municipalities and counties in Pennsylvania and discussed the problem of suppressing the discharge from gob piles to meet such requirements.

Water sprays appear to be effective only if constantly maintained. Some success has been attained by the injection of limestone grout under pressure into the pile through perforated pipes; or in one instance a severe fire was isolated by trenching across the pile and filling the trench with spent material taken from a lime-and-soda feedwater softening plant. However, a recent study of 329 coal mining operations in the United States showed that no particular method would yield unqualified success.

Changing Characteristics of Storage Coal

Thomas F. Downing, Jr., of Philadelphia Electric Company, reviewed a study that was prompted by operating difficulties encountered while burning stored coal at his company's Richmond Station in 1941. This study led to the following conclusions:

1. Spontaneous combustion in piles of properly placed central Pennsylvania low-volatile coals should not occur after 18 weeks in storage.
2. In these coals, ash-fusion temperatures and sulfur definitely change and other constituents probably change with time in storage.
3. Breakdown of pyritic sulfur contributes materially to ash-fusion temperature increases.
4. Changes in stored coal characteristics occur to depths of excess moisture penetration.
5. Most added moisture within a coal pile is carried there by winds.
6. Covering pile surfaces will at least delay moisture and air penetration.
7. Penetration by air and moisture can be retarded by denser compaction.
8. Coking characteristics may deteriorate to the extent of making coal unsuitable for the originally intended use.
9. Proportionate tonnages subject to changes are dependent largely upon shape or width of the pile base and length of time in storage.
10. Methods of and equipment for storing and recovering can materially affect economy in storage operations and plant utilization.

A second panel discussion dealt with fuel and equipment consulting service for the small steam plant from the viewpoints of the owner, the coal producer, the consulting engineer, equipment manufacturer and the construction contractor.

The Owner's Viewpoint

Speaking for the plant owner, **A. R. Miller,** power engineer of General Foods Corporation, cited, as typical, the case of his company which has 24 steam plants rated between 5000 and 50,000 lb of steam per hour, of which 17 are fired by coal and 7 by oil. Of the former, 13 are stoker-fired and 4 hand-fired, and the average yearly coal consumption is 1600 tons per plant. The average annual operating cost amounts to $27,000 per plant, of which

$15,000 represents fuel, $10,000 operating labor, and $2000 maintenance. Efficiencies range from 60 to 70 per cent.

In most of these plants there is a single operator per shift and in a few there is an extra man on the day shift to unload coal, handle ashes and perform general housekeeping.

The manager of the entire plant of which the small steam plant is a part usually cannot be expected to know much about the generation of steam, as he is primarily interested in the product manufacture and the purchase of raw materials. Hence, where a problem arises in the steam plant necessitating the installation of equipment, the decision is likely to be influenced by the least immediate expenditure without making an economic survey. It may be difficult to justify equipment aimed solely at increasing the efficiency where a 10 per cent increase may represent perhaps only a $1500 annual saving in the fuel bill. Labor cost becomes important only when a second operator is needed.

Coal Producer's Viewpoint

Earl C. Payne, of Pittsburgh Consolidation Coal Company, proposed that a program and organization be set up by the coal industry, under the National Coal Association or Bituminous Coal Research, Inc., to coordinate the consulting and engineering service activities of regional advisory committees. The object would be to raise the standards of plant operation for existing equipment and, where indicated, to promote modernization. This would involve a technical program to supplement and assist the normal direct sales by coal producers, distributors and retailers.

He proposed further that standardized package plants and approved coal specifications be made available through consulting engineers, and that plant owners be encouraged to employ competent consulting engineers for analyses of load conditions, to make layouts, and supervise construction.

It was estimated that small steam plants constitute a market for 75 million tons of bituminous coal annually, but in recent years this has been declining, due to inroads of competitive fuels. However, because of unstable international conditions and more or less limited reserves of oil and gas, there may be a reversal of this trend.

Small coal-burning plants, said Mr. Payne, often tend to degenerate through incompetent or careless operation, use of improper fuel or inadequate maintenance. Sometimes this leads owners to turn to higher priced competitive fuels—a situation that could be forestalled by competent fuel engineering service.

The coal industry is made up of 7700 producing companies operating 8700 mines in 25 states. Only 210 of these companies produce more than a million tons annually.

Viewpoint of the Consulting Engineer

H. C. Carroll, Chicago consulting engineer, confined his remarks to steam plants in the range of 100 to 500 hp where there is normally only one engineer or fireman on duty per shift, who also handles ordinary maintenance.

The fact that the consulting engineer is not called in more often in connection with such plants Mr. Carroll attributed (1) to the architects who either have their own mechanical engineers or sub-contract such work; (2) to the high cost of solicitation of the small plants by consulting engineers; and (3) to the practice of many equipment manufacturers and contractors of contributing free advice and service.

The normal procedure for consulting engineering service in these small plants is to obtain the objectives of economical operating costs in much the same way as for larger plants. This involves a preliminary survey and report covering the scope of the problem together with recommendations and estimates before proceeding with the work. Since operating records are usually meager and instruments inadequate, tests may be necessary in order to obtain the required data. Also, where reliable plant layouts are lacking it becomes necessary for the consulting engineer to take measurements and make layouts in order to determine space limitations and investigate possibilities of equipment arrangements before specifications can be drawn and issued for competitive bids. Following this, general supervision by the engineer is necessary in order to insure that the plans and specifications are carried out.

Mr. Carroll added that another valuable service can be rendered by the consulting engineer in maintaining efficient operation after the plant is in service.

Construction Contractor's Viewpoint

The construction engineer, according to **W. S. Major** of Dravo Corporation, generally functions as an aid to the consulting or plant engineer through development of the many details that are necessary before the steam plant becomes a reality. Many of the operating problems and high operating costs of small plants emanate from limitations of plant design, which can often be traced to inadequate advance study of the fuels available throughout the plant's probable life. As a result, one finds many small boiler plants with one or more of the following limitations: (1) inadequate grate area; (2) too small furnace volume; (3) poor furnace configuration; (4) incorrect type of stoker; (5) furnace limited to use of liquid or gaseous fuel; (6) restricted working space for routine servicing and maintenance.

There is failure in many cases to make a comprehensive fuel and equipment study in advance of plant design, which Mr. Major attributed to the fact that the small steam plant is often considered incidental to the construction of a small manufacturing plant or other commercial business. The architect, not being a specialist in steam plant practice, will inadvertently overlook many features that promote efficient operation. Furthermore, many of these plants were built when fuel prices and labor rates were relatively low.

In the modernization of existing small plants and the design of new ones, there are many operating conditions not common to larger steam plants and, unless these factors are properly analyzed, the costs of improvements may be out of proportion to the potential gains.

While there is little question as to the needs and benefits of consulting engineering service for small steam plants, fuel costs in many cases form such a small percentage of overall manufacturing costs that owners fail to appreciate that fees for consulting service pay good dividends.

Boost for the Coal-Burning Locomotive

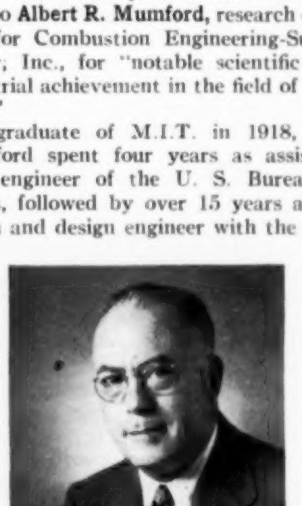
Speaking at the Thursday luncheon, **R. H. Smith,** president of the Norfolk & Western Railroad, stated that of the country's twenty-three principal railroads his was the only one that had clung exclusively to the steam locomotive; yet a study of performance records submitted to the Interstate Railway Commission showed the all-around freight operating efficiency of the N & W in 1950 to have surpassed any of the other twenty-two carriers. This was on the accepted basis of gross ton-miles per train-hour. Results so far this year indicated that the 1950 performance would be bettered. He attributed this to the fact that N & W has 487 of the most modern locomotives, built in its own shops, employing roller-bearing axles, automatic lubrication and serviced by the most up-to-date methods so as to attain a maximum use factor. Moreover, it has been found most economical to burn a good quality of properly sized coal.

The principal speaker at the banquet was **W. S. Newman,** president of Virginia Polytechnic Institute, who discussed engineering education and referred to the demand for technically trained men.

Percy Nicholls Award

A feature of the banquet was the presentation of the Percy Nicholls Award for 1951 to **Albert R. Mumford,** research engineer for Combustion Engineering-Superheater, Inc., for "notable scientific and industrial achievement in the field of solid fuels."

A graduate of M.I.T. in 1918, Mr. Mumford spent four years as assistant fuels engineer of the U. S. Bureau of Mines, followed by over 15 years as research and design engineer with the New



Albert R. Mumford

York Steam Corporation; then four years as assistant director of research with Consolidated Edison Company of New York. He joined the Research Department of Combustion in 1942. The citation recognized Mr. Mumford's contribution to advances in utilization of fuels through his researches on combustion of coal, heat transfer and circulation in steam generating units, particularly his direction of the work of the ASME Special Research Committee on Furnace Performance Factors.

ASME Annual Meeting Program Briefed

THE 72nd Annual Meeting of the American Society of Mechanical Engineers will be held at the Chalfonte-Haddon Hall Hotel in Atlantic City, N. J., November 26–30. A widely varied program of over 220 technical papers will be presented at more than 90 sessions to be sponsored by 34 professional divisions and committees of the Society in what is expected to be the biggest meeting ever held by ASME.

Prominent figures in industry, engineering and education will address the gathering at luncheons and dinners, as well as technical sessions. They will be welcomed at the traditional "President's Luncheon" on the opening day by J. Calvin Brown, ASME president, who will speak on the subject, "Benjamin Franklin—Statesman, Diplomat, Inventor, Author."

William L. Batt, head of the Economic Cooperation Administration for Great Britain, will be the principal speaker at the Annual Banquet on Wednesday evening.

The Roy V. Wright Lecture on citizenship responsibilities of engineers will be delivered by W. C. Mullendore, president of Southern California Edison Co. At one of the management sessions, Ewan Clague, U. S. Commissioner of Labor Statistics, will talk on "This Thing Called Productivity."

The following listing of papers and events is based upon the preliminary program. Since these arrangements are only tentative, persons planning to attend specific sessions will find it advisable to make confirmation by contacting ASME headquarters prior to the Annual Meeting.

Items of Interest in the Power Field

Monday, Nov. 26, 9:30 a.m.

"Thermodynamic Charts for Gasification of Coal with Oxygen and Steam," by W. C. Edminster, H. Perry, R. Corey and M. A. Elliott, U. S. Bureau of Mines.

"Flow and Combustion Stability," by N. P. Bailey, Rensselaer Polytechnic Institute, Troy, N. Y.

Monday, Nov. 26, 2:30 p.m.

"The Gas-Turbine's Contribution to Gas-Line Pumping," by T. J. Putz, Westinghouse Electric Corp., Lester, Pa.

"A 5000-Hp Gas-Turbine Power Plant," by Bruce O. Buckland and Donald C. Berkey, General Electrical Co., Schenectady, N. Y.

"Design and Application of Waste-Heat Boilers," by K. J. Ray and R. Cubberly, Foster Wheeler Corp.

"Burning Fuel in a Fluo Solids Bed," by C. J. Wall, New England Lime Co.

Monday, Nov. 26, 8:00 p.m.

"Comparative Efficiencies of Central-Station Reheat and Nonreheat Turbine-Generator Units," by C. W. Elston and P. H. Knowlton, General Electric Co., Schenectady, N. Y.

"Thermal Performance of Modern Turbines," by H. R. Reese and J. R. Carlson, Westinghouse Electric Corp., Philadelphia, Pa.

"Diesel Fuel Performance," by R. W. Van Sant, Gulf Oil Corp.

"Commercial-Burner Oil Specifications," by I. V. Risek, Cleaver-Brooks Co.

"Fuel Requirements for Aircraft Gas-Turbine Engines," by L. C. Gibbon, Lewis Laboratory, National Advisory Committee for Aeronautics.

Tuesday, Nov. 27, 9:30 a.m.

"Modern Reheat Turbines—Recent Experience and Design Progress," by C. Schabtach and R. Sheppard, General Electric Co., Schenectady, N. Y.

"Present Development of the Reheat Steam Turbine," by R. L. Reynolds, Westinghouse Electric Corp., Philadelphia, Pa.

"Operating Experience with Stationary Gas Turbine," by Paul R. Sidler, Brown Boveri Corp., New York, N. Y.

"Behavior of Water Particles in Wet-Compression Process of an Axial-Flow Compressor," by S. L. Soo, Harvard University, Cambridge, Mass.

Tuesday, Nov. 27, 2:30 p.m.

"Operation and Performance of Modern Reheat Boilers," by P. R. Loughin and H. H. Poor, The Babcock & Wilcox Co., New York, N. Y.

"Some Design Factors Relating to Performance and Operation of Reheat Boilers," by H. H. Hemenway, Foster Wheeler Corp., New York, N. Y.

"A Progress Report of Reheat Boiler Operation and Design," by W. J. Vogel, and E. M. Powell, Combustion Engineering-Superheater, Inc., New York, N. Y.

Panel: "Spreader-Stoker Design for Light Load Operation"

Speakers: F. C. Messaros, American Engineering Co.; M. O. Funk, Combustion Engineering-Superheater, Inc., New York, N. Y.; H. Wagner, Detroit Stoker Co.; E. C. Miller, Riley Stoker Corp.; D. J. Mosshart, Westinghouse Electric Corp.

"An Investigation of Gravity Reinjection of Fly Ash to a Spreader-Stoker-Fired Boiler Furnace," by C. H. Morrow, J. I. Case Co., W. C. Holton, Battelle Memorial Institute, and H. Wagner, Detroit Stoker Co.

Tuesday, Nov. 27, 8:00 p.m.

"Reheat Experience at Port Washington," by M. K. Drewry, Wisconsin Electric Power Co., Milwaukee, Wis.

"The First Year's Experience of the Dunkirk Steam Station," by J. N. Ewart, Niagara Mohawk Power Corp., Buffalo, N. Y.

"Twenty-Five Years of Reheat Operating Experience on the American Gas and Electric System," by S. N. Fiala, American Gas and Electric Service Corp., New York, N. Y.

"Operating Experience with Reheat at Edgar Station," by H. E. Stickle, Boston Edison Co., Boston, Mass.

"Impact of Defense Activities on Petroleum Fuel Supplies," by Adam K. Stricker, General Motors Corp.

Wednesday, Nov. 28, 9:30 a.m.

"The Development and Implementation of a Generation Program on the American Gas and Electric Company System—I. System Fundamentals," by Philip Sporn, American Gas and Electric Service Corp., New York, N. Y.

"The Development and Implementation of a Generation Program on the American Gas and Electric Company System—II. Fuel Supply," by Philip Sporn and H. A. Kammer, American Gas and Electric Service Corp., New York, N. Y.

"The Development and Implementation of a Generation Program on the American Gas and Electric Company System—III. 200,000 Kw, 2000 Psi, 1050 F—An Advance in the Economics of Integrated Power System Generation," by Philip Sporn and S. N. Fiala, American Gas and Electric Corp., New York, N. Y.

Wednesday, Nov. 28, 2:45 p.m.

"An Investigation of the Variation in Heat Absorption in a Natural-Gas-Fired Water-Cooled Steam-Boiler Furnace," by Albert R. Mumford, Combustion Engineering-Superheater, Inc., New York, N. Y., and Richard C. Corey, U. S. Bureau of Mines, Pittsburgh, Pa.

"Design Features of a 250-Kw Gas-Turbine Engine for Driving Shipboard Emergency Generator," by R. R. Peterson, Navy Dept., Bureau of Ships, Washington, D. C., and Paul G. Carlson, Solar Aircraft Co., San Diego, Calif.

"Self-Induced Vibrations in Axial Compressor Blading" (a motion picture), by P. R. Sidler, Brown Boveri Corp., New York, N. Y.

Thursday, Nov. 29, 9:30 a.m.

"The Spectrophotometric Determination of Small Amounts of Soluble Silica in Water," by H. E. Robison, E. A. Pirsh and E. Grimm, Armour Research Foundation, Chicago, Ill.

"Adaptation of the Spectrophotometric Determination of Small Amounts of Soluble Silica in Water to the Determination of Undissolved Forms of Silica," by H. E. Robison and E. Grimm, Armour Research Foundation, Chicago, Ill.

"Correlation of Silica Carry-Over and Solubility Studies," by Clarence Jacklin and S. Robert Browar, National Aluminate Corp., Chicago, Ill.

"Graphitization in Catalytic-Cracking Unit Reactors," by D. B. Rossheim, J. J.

Murphy, W. B. Hoyt and H. S. Blumberg, The M. W. Kellogg Co., New York, N. Y.

"Embrittlement of 12 Per Cent Chromium Steels After Exposure to 750 F and 900 F, by M. A. Scheil, A. O. Smith Corp., Milwaukee, Wis.

Thursday, Nov. 29, 2:30 p.m.

"The Influence of Boiler Design and Operating Conditions on Steam Contamination," by Paul M. Brister, S. C. Raynor and E. A. Pirsh, The Babcock & Wilcox Co., New York, N. Y.

"Field Testing of Evaporator Vapor Sampling Nozzles," by E. B. Morris, American Gas and Electric Service Corp., New York, N. Y.

"Effect of Temperature Variations on the Long-Time Rupture Strength of Steels," by Ernest L. Robinson, General Electric Co., Schenectady, N. Y.

"A Time-Temperature Relationship for Rupture and Creep Stresses," by F. R. Larson, Watertown Arsenal, Watertown, Mass., and J. Miller, General Electric Co., West Lynn, Mass.

"High-Temperature Stress Rupture Testing of Tubular Specimens," by L. F. Kooistra, R. U. Blaser and J. T. Tucker, The Babcock & Wilcox Co., Alliance, Ohio.

"Rupture and Creep Characteristics of Titanium-Stabilized Stainless Steel at 1100 to 1300 F," by J. W. Freeman, Engineering Research Institute, University of Michigan, George F. Comstock, National Lead Co, and A. E. White, Engineering Research Institute, University of Michigan, Ann Arbor, Mich.

Thursday, Nov. 29, 8:00 p.m.

"Behavior of Superheater Tubing Materials in Contact with Combustion Atmosphere at 1350 F," by H. A. Blank, J. H. Jackson and A. M. Hall, Battelle Memorial Institute, Columbus, Ohio.

"Evaluation of Superheater Tube Materials for Steam Generation at 1100–1500 F," by Bela Ronay, U. S. Naval Engineering Experiment Station, Annapolis, Md.

"Experimental Superheater for Steam at 2000 Psi and 1250 F—Progress Report of Field Operation," by F. G. Ely and F. Eberle, The Babcock & Wilcox Co., Alliance, Ohio.

Friday, Nov. 30, 9:30 a.m.

"Station Design with Cyclone-Fired Steam Generators," by H. C. Schroeder and R. I. Strasser, Sargent and Lundy, Chicago, Ill.

"Operating Experiences with Cyclone-Fired Steam Generators," by V. L. Stone, Commonwealth Edison Co., and I. L. Wade, Public Service Co., of Northern Illinois.

Items of General Interest

Monday, Nov. 26, 9:30 a.m.

The Training of Young Engineering Graduates in Industry:

"From the Standpoint of a Smaller Company," by G. W. Baughman, Union Switch and Signal Co., Swissvale, Pa.

"From the Standpoint of a Medium-Sized Company," by E. G. Bailey, The Bailey Meter Co., New York, N. Y.

"From the Standpoint of a Larger Company," by H. C. Houghton, Bethlehem Steel Co., Bethlehem, Pa.

Monday, Nov. 26, 12:15 p.m.—President's Luncheon

Speaker: ASME President, J. Calvin Brown.

Subject: "Benjamin Franklin—Statesman, Diplomat, Inventor, Author."

Monday, Nov. 26, 8:00 p.m.

"A Current Plan for Young Engineers," by Martin D. Whitaker, president, Lehigh University, Bethlehem, Pa.

Tuesday, Nov. 27, 9:30 a.m.

"This Thing Called Productivity," by Ewan Clague, United States Commissioner of Labor Statistics, Washington, D. C.

Tuesday, Nov. 27, 12:15 p.m.—Fuels Luncheon

Speaker: C. E. Davis, Petroleum Administration for Defense.
Subject: "Petroleum—Our Resources and Production".

Tuesday, Nov. 27, 5:00 p.m.—Roy V. Wright Lecture

Lecturer: W. C. Mullendore, president, Southern California Edison Co., Los Angeles, Calif.

Wednesday, Nov. 28, 12:15 p.m.—Honors Luncheon

Presiding: Incoming President, R. J. S. Pigott
Conferring of honors:
Hoover Medal: William L. Batt, head, Economic Cooperation Administration for Great Britain, London, England.
Gantt Medal: Thomas Roy Jones, president, Daystrom, Inc., Elizabeth, N. J.
Fritz Medal: E. G. Bailey, vice-president, Babcock & Wilcox Co., New York, N. Y., and chairman, Bailey Meter Co., Cleveland, Ohio.

Wednesday, Nov. 28, 2:45 p.m.

"Productivity Through Stabilized Operation," by E. H. MacNiece, Johnson & Johnson, New Brunswick, N. J.

"Moral and Spiritual Concepts in Production," by Erwin H. Schell, Massachusetts Institute of Technology, Cambridge.

Wednesday, Nov. 28, 6:45 p.m.—Annual Banquet

Speaker: William L. Batt, head, Economic Cooperation Administration for Great Britain.

Thursday, Nov. 29, 5:00 p.m.

"The General Philosophy of Co-Operation Between the Atomic Energy Commission and Industry."

First "Supercharged" Generator

The world's first "supercharged" generator has recently been placed in service at the Edgewater plant of the Wisconsin Power and Light Co. in Sheboygan, Wis. This 60,000-kw, 12,500-volt, 3600-rpm Allis-Chalmers steam-turbine-driven generator embodies a new principle which is said to save 30 to 40 per cent of the material of a normal 60,000-kw machine.

The reduction in weight and length is achieved by forcing hydrogen, at much higher velocity than has been used before, directly over the surfaces of the current-carrying copper conductors of the rotor. In addition to the normal fans for circulating the hydrogen, there is a two-stage centrifugal compressor, much like an oversize aircraft supercharger, mounted at one end of the shaft. To speed up removal of heat from the rotor the designers devised specially shaped copper windings through which cool hydrogen travels at high speed. After being heated in passing through the rotor, the hydrogen is cooled by conventional water-to-hydrogen heat-exchangers.

The heat removing ability of the supercharged design is demonstrated by test data showing that in less than one-fiftieth of a second hydrogen passes through the full length of the rotor passages of a 60,000-kw machine, while at the same time it absorbs enough heat to raise the temperature to 90 F.

In addition to the large savings in copper and steel several other important advantages are claimed such as less turbine room space resulting from the shorter rotor and reduced rotor removal space required, as well as smaller foundations. Also short-circuit currents are substantially reduced, with consequent savings in the cost of circuit-breakers, reactors and other equipment and with less damage likely to occur in event of short-circuit.

BOOKS

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Principles of Engineering Economy

Third Edition

BY E. L. GRANT

623 pages Price $5.00

The Third Edition of this well-known engineering text continues the practice of stressing the question, "Will it pay?" in considering economic alternatives of technical projects. Although the general plan of organization has been maintained and places major emphasis on techniques for economy studies, more than two-thirds of the book has been rewritten.

New material has been added which discusses the treatment of prospective price changes, something which assumes considerable importance in engineering planning of the present. The chapter on theoretical aspects of replacement economy has been revised in accordance with an approach developed by George Terborgh of the Machinery and Allied Products Institute. New chapters have been added entitled "The Relationship of Income Taxes to Economy Studies" and "Further Examples of Economy Studies in Manufacturing Industries and Public Utilities."

There are many new problems, bringing the total to 400. Of these about 30 per cent have answers, making the text useful for self study.

Plant Engineering Handbook

EDITED BY WILLIAM STANIER

2000 pages Price $15.00

This is a book intended to supplement the usual type of engineering handbook for those people in industry who are responsible for organization, design, construction, operation and maintenance. It was prepared by a staff of 87 specialists from 45 industrial organizations and five universities.

The opening section, "Basic Costs and Cost Reduction," is useful for making estimates in which long-term effects are important considerations. In addition to costs this chapter provides data on man-hours per unit on such commodities as food products, textiles, paper, chemicals, rubber, leather, iron and steel, machinery, automobiles and coal mining. Succeeding sections take up various aspects of management engineering, construction materials and structural design, fire prevention, plant maintenance, water treatment, power plants, etc.

The section on power plants makes up nearly 15 per cent of the handbook and is quite comprehensive in its coverage of power-plant thermodynamics, fuels, fuel preparation and burning equipment, boilers and boiler auxiliaries, graphic power measurement, steam turbine-generators, gas turbines, compressors and pumps, hydraulic turbines, mechanical-drive turbines, and ash-handling systems. Some of the material on boilers and fuel burning equipment has been adapted from *Combustion Engineering*, edited by Otto de Lorenzi. A concise summary of power-plant thermodynamics was prepared by H. L. Solberg and C. L. Brown of Purdue University, and an informative contribution on gas turbines was written by Dr. J. T. Rettaliata.

Mechanical Engineers' Handbook

BY LIONEL S. MARKS, EDITOR

6 × 9 Price $15.00

This new Fifth Edition of the well-known "Mark's Mechanical Engineers' Handbook" represents a complete revision in which more than a hundred engineers, each a recognized authority in his special field, have cooperated to produce a 2236-page volume of carefully selected data on practically every branch of mechanical engineering.

Significant recent developments discussed under the heading of "Theory" are fluid mechanics, stresses in turbine disks, transonic and supersonic aerodynamics, aircraft jet propulsion, rockets and television. Under "Processes" the text takes up radiant or panel heating, solar heating, high-vacuum pumps, industrial supersonics, modern casting methods, statistical quality control and automatic process control.

Furnished also is new or greatly revised information on the materials of engineering, such as ferrous and non-ferrous alloys, super-alloys for highest temperatures, plastics, elastomers, silicones, adhesives, rocket fuels, reflective heat insulation and powder metallurgy. Power costs are analyzed in the light of current conditions, as are gas turbines and atomic energy as power sources.

The sixteen sections that make up the text are: Mathematical Tables and Weights and Measures; Mathematics; Mechanics of Solids and Liquids; Heat; Strength of Materials; Materials of Engineering; Fuels and Furnaces; Machine Elements; Power Generation; Hoisting and Conveying; Transportation; Building Construction and Equipment; Machine-shop Practice; Pumps and Compressors; Electrical Engineering; Engineering Measurements, Mechanical Refrigeration.

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